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Part II (pp. 158-341)

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RESEARCH ON SUGAR PLANTS AND SOME PRACTICAL ADAPTATIONS

(Address before the Second General Meeting, American Society of Sugar Beet Technologists, Denver, Colo., Jan. 5, 1940.)

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The title selected for this informal talk is "Research on Sugar Plants and Some Practical Adaptations." That is a broad subject and gives the opportunity to speak at length, but I will limit my remarks to a half dozen lines of work sponsored by the Division of Sugar Plant Investigations during the past two decades. An appraisal of the value of this research to American Agriculture will be recapitulated, showing that in this period a total approaching one billion dollars of conserved capital and added national wealth is directly attributable to it and indirectly many millions more have gone to "good neighbors." Nor are the results to be evaluated only in monetary units, since at present a half million of our people who might otherwise be on relief have means of livelihood because of this research, which, relatively, has cost little.

The realistic view demands that these benefits be credited as net gains with no deduction for compensating factors, such as possible other uses of the land and labor, or possible income of any kind derived indirectly. We have a long-established, firmly-rooted domestic sugar industry. That is a sufficient reason for the successful efforts to make it more efficient. Nor are the ramifications of these contributions to national wealth limited to the producers who benefited directly by the results of this research, as these producers in turn constitute a market for American goods greater than that which might come from potential producers elsewhere.

In comparison with other sugar-producing areas, the United States has made much progress in the improvement of the sugar plants during the past 20 years. In that period there has been a series of interruptions in growth of the several sugar industries, in the main resulting from natural causes adversely affecting the plants themselves. These natural causes, chiefly plant diseases, more than any other factors have threatened the continued existence of the industries. Their impact on the industries and their effects on growth have varied in duration and degree and have been different in character.

Intimate knowledge of these natural causes as they affect production units represented by plantations or farms is required if reliable interpretation of production statistics is to be made. Broad interpretations of production trends without such intimate knowledge, especially of extensive areas, are likely to be imperfect. The interruptions of productivity of our sugar industries during the past 20 years were characterized, for example, by practical collapse in Louisiana and the South, violent and unpredictable annual fluctuations of output in the western beet areas, and curtailment, lesser in amount than in Louisiana, followed by temporarily retarded recovery in Puerto Rico.

The ominous nature of the situation in the South in the period from 1918 and culminating in 1926 was apparent to all without need for intimate knowledge of the cause. But reaction to it by observers was not unanimous and the differences lay in ability to ascribe the cause and visualize the chances of any remedial measures. A well known economist immediately sounded the death knell of the industry and no prudent financing institution was willing to risk a dollar on it. The income of sugar farmers in Louisiana dropped to such a

pitiful figure that the State's leading advisor in agriculture complacently drew attention to the fact that a minor poultry industry was more profitable. However, a small group of growers was persuaded that the natural cause of the calamity could be determined and that some control could be found, and they met the challenge rather than passively submitting to what many took to be inexorable force. They seized upon the hope of remedial measures then offered and those in prospect, and with indomitable will literally lifted themselves by their own bootstraps. The remedy offered was a botanical specimen unprepossessing in appearance, which elicited some amused if not derisive comment at first, even by the man who later with self-effacing public spirit contributed the same means of salvation to thousands of his neighbors. He lost his own plantation because the remedy came too late.

Reduced to simple terms, the recent decline of the Louisiana sugar industry was due to the unnoticed introduction of the virus disease of sugarcane, mosaic, which met an unprepared industry not provided with adequate research facilities. The lesson in unpreparedness cost the industry more than can be measured in money. Adjustment of whole communities to a calamity bringing universal loss of revenue brought the gravest personal and family problems and, because of the lack of other enterprise to turn to, an unwholesome resignation. In the end, after costly delay, a reasonably satisfactory solution was found in the improvement locally of sugarcane varieties by breeding for resistance to disease and adaptation to our climate and soils. This involved an elaborate program of scientific work after literally combing the world for breeding material. Details of the main and accessory projects by a dozen specialists have been reported in numerous publications, and need not be enumerated here.

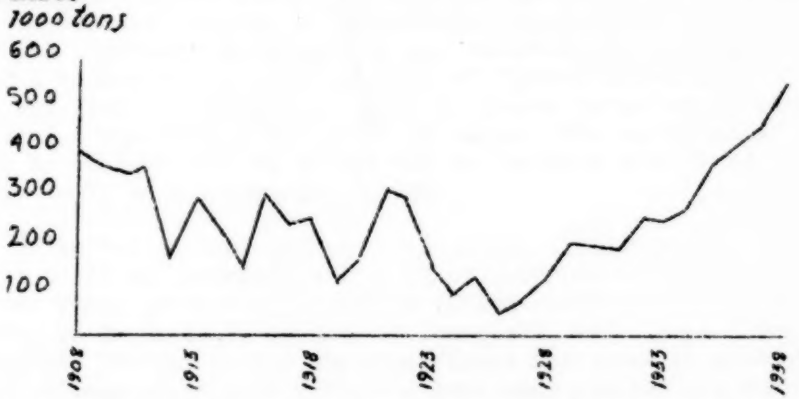


Fig. 1. Sugar Production From Cane, United States, showing crop failure due to disease, and reconstruction of the industry with disease-resistant varieties to all-time high sugar production arising from record acre yields.

The practical adaptation of this research is graphically shown by the production figures in Figure 1, which indicate that beginning with the year 1927, when the first new variety was increased to acreage reflected in the statistics, there has been a constant rise as variety succeeded variety in the gradual development of better sorts by breeding. The actual increase in production was from less than fifty thousand to nearly five hundred thousand tons of sugar, the acreage in cane[1] for the ten-fold increase being only about double.

1/ Some of the acreage planted in 1926 was not harvested.

A similar visitation of disease caused by the same or related viruses occurred in Puerto Rico, where studies were begun by the Division of Sugar Plant Investigations earlier than in the Gulf States. Because of great local variation in weather, indirectly affecting the efficiency of natural dissemination of the virus the problem in Puerto Rico resembled that in Louisiana only in part. In some districts it is possible by a system of almost constant roguing to grow susceptible varieties of cane even today. Because of the expense and potential danger, that is not a wholly satisfactory system and requires further attention. Other districts representing a large percentage of the total area in cane required substitution of resistant varieties.

The history of discovery and development of resistant varieties for Puerto Rico was analogous to that on the mainland, except that, due to more exacting demands of climate in the latter area, finding suitable breeding material required a more thorough search. Without the background of fundamental research carried on by the Division, the sugar industry in Puerto Rico would be in a far less flourishing condition today and the same can be said of the relatively new industry in Florida, which faces other unsolved problems because of its position intermediate between tropical and temperate zone conditions. Parenthetically, the sugarcane virus disease problems the world over and their solution by "variety revolution" or other means received their present conception, and the inspiration and methods of control, because of the appropriations by Congress of money for this research.

Beyond mere repair of the disease injury, the improved tone and tempo of sugarcane yields so easily perceived in many plantations of Cuba and the West Indies generally, South American countries, and to some extent in Africa, Oceania and Asia, even the little industry in southern Spain, trace a measure of their current impetus to this research. Twenty-two countries have safely received improved plant material for which the Division acted as a clearing house, whatever its origin, by maintaining a quarantine station. Encouragement lent by the improved performance of the resistant or tolerant varieties led, by natural reasoning, to consideration of further improvement by other means and has resulted in substantial gains to levels never before reached, this in the face of a declining world price of sugar. The sum total of benefits to humanity by conservation of effort and in lessened cost of an indispensable commodity would be a staggering amount.

To arrive at the estimate of American dividends paid by this research we credit to it all production with plant material released by the Division used where sugar production had quite failed owing to low yield, and a part of production on lands that, because of low yield, were jeopardized but not actually abandoned. On the latter the significant increases in production since the improved, disease-resistant varieties have been planted are very great and are just as directly attributable to this research.

In addition, we credit the capital investment in factories, machinery, plantation railways, and specialized implements and equipment in the areas definitely marked for abandonment or already abandoned. If solutions had not been found for these field problems, all fabrication equipment would have had junk value only. On that basis we boldly assert that the Gulf States sugar and sirup industries owe to this research over a period of 14 years three-hundred and fifty million dollars and the present employment of 60,000 workers, with an average of three dependents each, or a total of 240,000 persons.

The increased per acre production in Puerto Rico, beginning in 1919 when the first mosaic resistant variety was supplied, has been steady and has now reached over 100 percent.* While the prompt clarification of the perplexing disease problems, the early resistant varieties, and guidance were directly contributed by the Division of Sugar Plant Investigations, continuance of the work by local research institutions and added improvement must be recognized; therefore, one-half of the annual increments in per-acre yield since that date, a total of two hundred and twenty-five million dollars, is the claim. In this industry, which as a whole was not threatened with extinction, credit for salvage of capital investment is relinquished, except for factories supplied by the worst-affected 70,000 acres, and the workers thereon, respectively ten million dollars and livelihood for 25,000 workers. That these workers and dependents, 100,000 people, would have found other gainful employment in the present depressed period for the agricultural industries is less likely than the alternative, enlistment in the army of unemployed.

This record of the southern sugarcane industry laid prostrate by a virus disease finds counterpart in the ravages of sugar-beet curly top in western United States. The effects of the disease have been grave enough and so widespread in many years of the decade preceding 1934 as to bring about sharp decline in the average acre-yields of a whole state. In such years of disease outbreak, the factory records reveal that average acre-yields in some districts have dropped precipitously from the expected 15 tons or more to 5 tons or less. Such figures, based on harvested acreage, obviously give no record of thousands of acres abandoned.

As throwing light on the impact of curly top on the beet-sugar industry, one may trace the history of sugar-beet culture in western reclamation projects or other agricultural areas in the West—such as the Truckee Project, Salt River Project, Delta and other Utah areas, the San Joaquin Valley of California, the Yakima Valley of Washington, and many others. The story is much the same for all—introduction of the crop, a brief period of fine prospects, and finally crop failure because of curly top, and ultimate abandonment of sugar-beet growing by farmers.

The history of factories erected with high hope and welcomed by farmers on the irrigated lands as providing a market for the pivotal cash crop in the agricultural program also portrays the emergency situation that curly top brought about. Each venture represented the investment of upwards of one-half million dollars. The subsequent history of these beet-sugar factories is a drab picture of idle years or, at best, sporadic activity as one season's crop or another by some vicissitude of climate managed to escape a disease epidemic. A factory erected in the Yakima Valley operated only a few days in a single season, then was closed and eventually dismantled. Curly top practically made the beet-sugar industry in western United States lead a gypsy existence in its futile quest to find some reasonably secure areas in which to grow the sugar beet.

No business could long continue under these conditions and by 1929 the western beet-sugar industry was at its lowest ebb and bankruptcy was imminent for many enterprises.

But these failures of capital to yield returns, the losses of original investments, and the collapse of many ventures in spite of constant outlay of new capital, signify far more than mere money losses. In essence, they are faithful indices of far-reaching and profound effects upon the agricultural

*Fig. 2, page 163a.

population and on the agricultural system of the West. On the human side, they involve disappointment, wastage of human effort, and wreckage of farm families. Wherever a factory was forced to stand idle because of the sugar-beet crop failure because of curly top,the livelihoods if not the fortunes of several hundred farmers around the factory were jeopardized.

In 1929, Congress recognized the emergency situation and appropriated a considerable sum for investigation of the beet leaf hopper and the virus it transmits. These funds for research on the disease have permitted an augmented attack on the whole problem and prompt capitalization on all the promising leads developed by earlier research of this Division. It was possible in 1931 to demonstrate the first progress in the development of curly-top-resistant varieties. By 1933, steps were under way to increase the seed of a variety that was introduced in 1934, under the designation U. S. 1, for use by farmers.

Since that time, other curly-top-resistant varieties have followed in quick succession--U. S. 34, U. S. 33, U. S. 12--each representing an improvement in curly-top resistance and adaptation. The industry has fully cooperated to bring each of these improved varieties promptly to the growers, as is shown by the record that of about 300,000 acres subject to curly top, 235,000 acres were planted in 1939 with varieties arising from this research, and much of the remainage acreage was planted with curly-top-resistant varieties in some degree akin to government releases.

The removal of the threat of failure to the beet crop, through the continued improvement in resistance of beet varieties, is signalized by the rebuilt factory in the Yakima Valley--erected on the foundation of a factory formerly dismantled--the erection of new factories in California, Utah, Idaho, and the re-entrance of the sugar beet into districts of California, Nevada, Idaho, Utah, New Mexico, and western Colorado.

It can not be said that curly top is vanquished, because with severe exposure in the worst years it still takes some toll and prevents the crop from delivering the maximum which soil and climatic conditions might warrant. Beet farmers may now plant these new varieties with confidence that the crop will be carried through to a reasonably high yield in spite of disease, and they look forward to new and even better adapted varieties as further research fits the curly-top-resistant types to the great range of conditions encountered in the broad expanses of our sugar-beet areas.

If one seeks to appraise the benefits of this research effort, which has involved a dozen or more scientific workers and has had the wholehearted cooperation of the industry, he must take into account the dire condition into which curly top had forced the western producers. He must also have enough confidence in the American way of life to want American industry not only to be maintained but to grow.

The capital investment in farm lands, farm equipment, irrigation systems, factories, factory equipment, transportation and power facilities directly concerned in sugar-beet production and beet-sugar manufacture in the United States as a whole may be placed at $350,000,000. The capital investment in important subsidiary industries which furnish supplies and services to the beet industry and the livestock industry directly concerned in utilizing sugar-beet byproducts as feed would greatly increase this figure. Nearly one-fourth of this entire investment, amounting to between $80,000,000 and $100,000,000, was jeopardized. Is it not fair to credit the research which turned the tide from bankruptcy to

a surge of growth and development, as typified by the recent $25,000,000 expansion of the western industry, with saving and safeguarding a major share of this national wealth?

Moreover, progress in agricultural research refuses to confine itself to the narrow limits of the single problem-reaching solution, but it serves as a leaven for a whole agricultural complex. The farmer with a promising crop is the one who gives it good culture, he secures the means whereby he can fertilize his crop, he arrives at the position which enables him to devote acreage to legumes to rebuild his soil. One finds specific illustration of the intimate coordination of research in the yoking of the Division's research on curly top with its investigations on sugar-beet-seed production. Dependence upon Europe for seed, a condition which lasted nearly a century, was recognized by many informed and able men as imprudent, but attempts to remedy this incongruous situation were sterile until seed of the curly-top-resistant varieties were produced commercially by the "American" method. The linking of two objectives in our program secured, in no small measure, the practical adaptation of this research.

Investigation sponsored by this Division had shown that sugar-beet seed could be efficiently produced in the United States by a new method which differed radically from the conventional European method which was lavish in its requirement of hand labor. Our investigations revolutionized the methods so that today we produce sugar-beet seed in the United States by short occupancy of the land in much the same way that winter wheat is produced, abundant use of machine dispensing with the hand-labor, "gardener" methods of Europe.

With the advent of curly-top-resistant varieties, the efficient method for increase of seed had been perfected by our investigations. We can be justifiably proud of the record that every pound of curly-top-resistant seed used on American farms has been home-grown. In 1939, more than 6,000,000 pounds of curly-top-resistant seed were produced. The American method of sugar-beet-seed production has also found use with improved varieties arising out of breeding work of commercial companies and with leaf-spot-resistant varieties coming from other research projects of this Division. In 1939, a total sugar-beet seed production in the United States reached a high of nearly 14,000,000 pounds, just a small amount below our total domestic requirements.(Fig. 3, p. 163a.)

History has repeated itself and Europe is again engulfed in war. But, in contrast to 1914, when the American industry was almost totally dependent upon Europe for the seed to plant the sugar-beet crop, we enter 1940 with a full-fledged sugar-beet seed industry which had its origin in American research and, in a way, was a byproduct of the investigations on curly top.

The files of the Bureau of Plant Industry of 1915, 1916, and 1917 give a vivid picture of that hectic period of World War days when, by dint of the strenuous effort of the Department of Agriculture, the Department of State, and only by the consent of the British government, passage through the blockade of Germany was secured for meagre amounts of sugar-beet seed, absolutely essential if a sugar-beet crop was to be grown in the United States. Such seed as filtered through cane in under bond that it would not be re-sold, and a bond that the sacks would be returned was exacted! Such are the grim realities of war time, where such an item as return of gunny sacks could determine whether an American food crop could be grown!

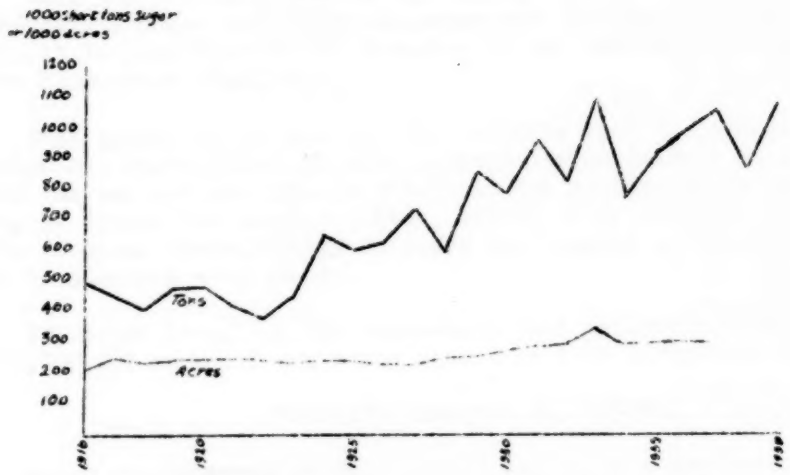
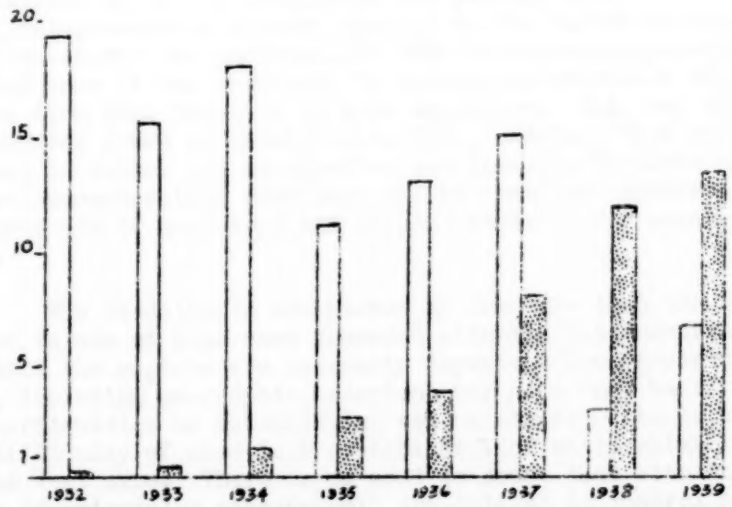


Fig. 2. Sugar Production from Cane, Puerto Rico, showing crop failure due to disease, and reconstruction of the industry with disease-resistant varieties to all-time high sugar production arising from record acre yields.



☐ Imports, in millions of pounds, for 12 months ending June 30.

▨ Domestic production, in millions of pounds, for planting in the year shown.

Fig. 3. Rapid Development of American Sugar-Beet-Seed Industry Brings Curtailment of Imports.

With the growth and functioning of an American seed industry, which is providing better seed to the American farmer than any that can be imported, and as a credit to American research and American ability to capitalize on research findings, the beet-sugar industry has freed itself from this foreign noose.

When the present European war largely cut off European supplies, the beet industry's house was nearly in order and seed supplies assured. Certainly by 1941, it is possible for all branches of the beet-sugar industry to have adequate home-grown supplies.

What appraisal is fair for the benefits that the domestic sugar-beet enterprise has contributed and will continue to contribute to our national welfare? As was not the case in the World War period, the beet-sugar industry can now, if demand for sugar requires, expand to do its part in supplying the nation's food—an impossibility 25 years ago because of the throttling effect of lack of adequate seed supply.

In direct benefits, the sugar-beet seed enterprise returns to farmers about $1,100,000 annually and a new source of farm income has been created.

PROMISING RESEARCH IN PROGRESS

Among the **numerous** projects under way but not yet practically adapted in the sense of large-scale translation into commercial practice, the work on cold tolerance of sugarcane and on black root and leaf spot of the sugar beet are examples of research that may soon be capitalized upon.

The improvement of temperate zone sugarcane to meet the hazard of unseasonably early cold has taken more definite form since the discovery in central Asia of cold-resisting wild cane in 1936. Progress has been made in overcoming the problems of cross-breeding due to the very different time of blooming of parent canes. Utilizing the reversed seasons north and south of the equator, the male parent was planted in the northern hemisphere, the female parent in the southern hemisphere, and while blooming simultaneously pollen was sent by airplane to cross-pollinate plants in the southern hemisphere. The seed was shipped by air to Washington and planted there and in Florida and Louisiana. The first-generation hybrids bloomed in the United States at a season intermediate between the two parents. To make backcrosses between the hybrids and commercial cane it was necessary to advance artificially the blooming time of the latter from late December to late September. This was accomplished by using a photoperiod house at Canal Point, Fla., a device that created autumn light conditions in summer and accelerated the blooming by three months. Thousands of the second-generation seedling will be ready for cold-resistant tests in 1940, and many are of good type and appear promising for sugar-production tests in 1941.

The traditional acceptance of the idea that the eastern sugar-beet region is one of high cost compared with the Intermountain and Pacific regions, and that the regions are unequally dependent upon protection afforded in various ways, including geographic location, may have some basis in two bugbears. These are difficulties of establishing and maintaining stands because of black root and difficulty of practical control of leaf spot, which is a problem in parts of the West also. There is no need to doubt that with intensive experimental tests of principles already well crystalized in control of black root, as seed treatments, rotations that starve the pathogenic organisms plus other field sanitation measures, and with adequate consideration of the separate needs of different districts in the humid area, the disheartening toll taken by this disease

complex can be greatly lowered. Because of local environmental differences in the districts of the humid area, a cure-all applicable everywhere should not be expected and therefore, more intensive tests are needed.

The leaf-spot-resistant sugar-beet variety U. S. 217, released in 1938, has demonstrated a high degree of resistance and under exposure to the disease has shown decisively better performance than the European brands with which it has been compared. Where leaf spot was not a factor the variety has been exceeded in root yield, and hence in sugar per acre, by certain improved tonnage types. A new leaf-spot-resistant release, U. S. 200 X 215, produces greater tonnage than U. S. 217, with practically equivalent sucrose percentage. To produce this variety, two inbred strains, which in themselves, regardless of leaf-spot-resistance, approximate European brands in performance, were intercrossed in order to take advantage of first-generation hybrid vigor. Tests in 1938 showed that the resistant variety exceeded the nonresistant check, taken as representative of European brands, by 333 pounds of sugar to the acre. The variety has as yet been produced only on a limited scale, something over 200,000 pounds of seed being available for 1939 commercial plantings.

It will be noticeable to you that the foregoing remarks have been limited to citing research activities of the Division of Sugar Plant Investigations. I am more conversant with details of those activities than with the numerous contributions to progress by others, and it is with no intention to slight their valuable basic steps, or parallel or accessory work on the same problems, that illustrations of practical adaptation of research were selected from those sponsored or vigorously pushed by the Division.

The raison d' etre of this talk is to emphasize in an impersonal way an idea that should be quickly recognized by biologists: the increasing control over living plant forms and their environments because of advances in biological and other science. Economic implications in the illustrations cited, with understanding of their extensive or limited use, are very great. The basis of the sugar industries is the mutable sugar-producing plant and very impressive are these recent demonstrations of opportunities to quickly change the character of plants in different producing areas with attendant changes in costs of production. Advances in plant breeding, unpredictable as to their impact upon the National economy, just as improvements in mechanics or chemistry, are sometimes far reaching and are likely to throw into confusion the calculations of economic planning.

REPORT ON 1939 TESTS OF U. S. 200 X 215

By G. H. Coons, Dewey Stewart, H. W. Bockstahler, J. O. Culbertson, G. W. Deming, J. O. Gaskill, J. G. Lill, and S. B. Nuckols.

Agronomic evaluation tests were conducted in 1939 on U. S. 200 X 215 and allied varieties by members of the staff of the Division of Sugar Plant Investigations in cooperation with Experiment Stations and with other cooperators, as shown, at 10 locations. In addition, Prof. J. H. Torrie of the Wisconsin Agricultural Experiment Station, Mr. M. J. Buschlen of the Farmers and Manufacturers Beet Sugar Association and Mr. H. D. Brown of the Canada and Dominion Sugar Company, Chatham, Ontario, conducted similar tests with the varieties supplied by the Division and have given permission to include in this report the data which they obtained. Mr. G. M. Bradford of the Monitor Sugar Co. of Bay City, Michigan, conducted two tests in which U. S. 217 and U. S.

200 X 215 were compared with several European brands, and he has supplied the data for use in this report. A total of 15 tests—6 in Colorado, 1 in South Dakota, 2 in Minnesota, 1 in Wisconsin, 4 in Michigan, and 1 in Ontario—are summarized.

Comparisons in table 1, except those for Bay City, and Au Gres, Michigan, are with 'Synthetic Check', a variety obtained by pooling equal quantities of 9 European brands and using this mixture to produce seed crop. In our experience, 'Synthetic Check' has shown a performance equivalent to the best European tonnage types and superior to many brands on the market. The 1939 results bear out this opinion, and in the absence of leaf spot, "Synthetic Check" proved a very strong competitor in several localities. In the Bay City and Au Gres tests, the average of all European brands included in the test is used instead of 'Synthetic Check'.

(Table 2)

Comparisons are also shown for U. S. 200 X 215 and some locally used brand or variety usually obtained from the Beet Sugar Company in whose territory the test was conducted. In the case of the Bay City and Au Gres test the European brand highest in sugar per acre was taken as the "Local Check".

Seed of U. S. 200 X 215 as used in all 1939 tests was commercial seed grown by the Western Seed Production Corporation in Arizona. The seed was produced from a planting stock made by mixing in proportions 1:3, commercial stock seed of U. S. 200 (highly leaf spot resistant inbred, high in sucrose, moderate in yielding capacity) and stock seed of U. S. 215 (a moderately resistant inbred, moderately high in sucrose, and of very high yielding capacity).

There is no way of determining with any degree of exactness how much intercrossing took place between the two inbreds in the seed field. U. S. 200 X 215, although indicated as a hybrid, consists of some unknown percentage of hybrids, along with selfs of the two inbred strains. Some experimental evidence exists that the cross of these two inbreds gives increased productiveness, and the introduction of this variety into commercial use represents an attempt to use in a practical way any advantage which might thus accrue from hybridizing.

In general, the data as summarized in tables 1 and 2 confirm the conclusions of the 1938 tests, namely, that U. S. 200 X 215 may be used to replace European brands in common use without reduction in sugar yields and that under conditions of leaf spot exposure, the variety may be expected to forge greatly ahead.

Table 1. SUMMARY OF 1939 TESTS OF U.S. 200 X 215
Conducted by Division of Sugar Plant Investigations
and cooperators.
Comparison with 'Synthetic Check' which approximates European tonnage types.
(Actual weight basis; results given as 10-plot averages except as noted.)

1939 Location of Tests	Acre Yield (Calculated) Indic.-avail. Sugar		Acre Yield (Calculated) Roots		Sucrose		Apparent purity coefficient		Stand 4/	
	US 200 X 215	Check	US 200 X 215	Check	US 200 X 215	Check	US 200 X 215	Check	US 200 X 215	Check
	pounds	pounds	tons	tons	%	%			%	%
Colorado:										
Ft. Collins Sta.(Sprinkler)	4,343	3,742	17.69	17.20	13.81	12.51	88.9	87.1	93.8	91.1
do. College Farm	4,147	4,231	13.04	13.79	17.16	16.52	92.52	92.64	92.8	93.3
Ft. Morgan 1/	6,447	6,114	20.98	21.52	17.24	16.23	89.20	87.6	88.5	84.7
Ault	5,109	5,438	16.50	17.53	16.78	16.88	92.2	91.8	88.0	87.8
Rocky Ford (Sprinkler)	5,733	5,026	25.27	25.08	12.72	11.54	88.70	87.08	121.0	116.0
do. West Ranch	5,386	5,715	17.64	19.06	16.53	16.31	92.59	92.18	124.0	105.0
Belle Fourche, S. Dak	3,882	4,347	13.3	14.6	17.0	17.3	85.7	85.6	63.0	61.0
Crookston, Minn. 2/	(2,644)	(2,880)	10.69	11.18	12.44	12.76	---	---	84.7	88.0
Waseca, Minn.	2,851	2,792	11.05	11.70	15.46	14.48	83.45	82.36	87.4	83.0
Madison, Wisc.	3,794	3,892	12.81	12.22	17.60	18.6	84.4	84.8	101.8	97.2
East Lansing, Mich.	3,026	2,803	10.0	9.2	17.4	17.5	87.2	87.1	82.5	91.9
Saginaw, Mich.	3,756	3,055	12.95	11.98	16.23	14.57	89.61	87.8	91.0	78.1
Bay City, Mich. 2/ 3/	(4,041)	(3,646)	12.38	11.23	16.32	16.24	---	---	103.0	101.0
Au Gres, Mich. 2/ 3/	(5,404)	(4,777)	16.01	14.85	16.88	16.09	---	---	128.0	126.0
Chatham, Ont.	2,534	2,020	9.46	7.8	15.40	15.0	86.7	86.5	87.6	67.6
Average	4,206	4,032	14.65	14.60	15.93	15.50	88.43	87.71	95.8	91.4
Difference	+174		+.05		+.43		+.72		+4.4	

1/ Fort Morgan test based on 5 replications.

2/ Gross sugar.

3/ Tests at Bay City and Au Gres, Michigan had 6 replications. Mean of all commercial varieties in test used as check.

4/ Stand in percent computed on basis of 12-inch spacing.

Table 2. SUMMARY OF 1939 TESTS OF U.S. 200 X 215
Conducted by the Division of Sugar Plant Investigations
and cooperators.
Comparison with European brand or variety supplied by the local beet sugar company.
(Actual weight basis; calculated from 10-plot averages except as noted.)

1939 Location of Tests	Acre Yield (Calculated)				Sucrose		Apparent purity coefficient		Stand 4/	
	Indic.-avail. Sugar		Roots							
	US 200 X 215	Check	US 200 X 215	Check	US 200 X 215	Check	US 200 X 215	Check	US 200 X 215	Check
	pounds	pounds	tons	tons	%	%			%	%
Colorado:										
Ft. Collins Sta.(Sprinkler)	4,343	4,035	17.69	18.20	13.81	12.64	88.9	87.7	93.8	93.3
do. College Farm	4,147	4,348	13,04	13.96	17.16	16.62	92.52	93.12	92.8	91.7
Ft. Morgan 1/	6,447	6,896	20.98	22.60	17.24	17.06	89.2	89.4	88.5	85.7
Ault	5,109	5,472	16.50	18.10	16.78	16.59	92.2	91.1	88.0	89.6
Rocky Ford (Sprinkler)	5,733	4,944	25.27	21.03	12.72	13.21	88.70	89.20	121.0	120.0
do. West Ranch	5,386	5,723	17.64	17.33	16.53	17.66	92.59	92.66	124.0	111.0
Belle Fourche, S. Dak.	3,832	4,096	13.3	13.8	17.0	17.3	85.7	85.8	63.0	57.0
Crookston, Minn.2/	(2,644)	(2,464)	10.69	10.28	12.44	12.00	---	---	84.7	69.7
Waseca, Minn.	2,851	2,484	11.05	10.83	15.46	14.02	83.45	81.85	87.4	66.2
Madison, Wisc.	3,794	3,869	12.81	11.82	17.6	18.6	84.4	87.5	101.8	94.5
East Lansing, Mich.	3,026	2,540	10.0	8.5	17.4	17.1	87.20	87.05	82.5	84.8
Saginaw, Mich.	3,756	2,983	12.95	11.53	16.23	14.74	89.61	87.45	91.0	72.0
Au Gres, Mich.	(5,404)	(4,941)	16.01	14.95	16.88	16.53	---	---	128.0	125.0
Bay City, Mich.	(4,037)	(3,811)	12.382	11.52	16.32	16.55	---	---	103.0	103.0
Chatham, Ont.	2,534	2,718	9.46	9.54	15.4	16.3	86.7	87.4	87.6	79.0
Average	4,206	4,083	14.65	14.27	15.93	15.79	88.43	88.35	95.8	89.5
Difference	+118		+.38		+.14		+.08		+6.3	

1/ Based on 5 replicates.

2/ Gross sugar.

3/ Tests at Bay City and Au Gres, Michigan are based on 6 replicates. Commercial variety showing highest sugar per acre used as check.

4/ Stand in percent computed on basis of 12-inch spacing.

BREEDING FOR RESISTANCE TO LEAF SPOT AND OTHER CHARACTERS

By H.W. Dahlberg, A. C. Maxon and H.E. Brewbaker[1/]

I believe this group may be interested in a brief statement of the objectives of the breeding program of The Great Western Sugar Company and the policies which we try to follow in attaining those objectives. Our main objective is the development of varieties that we may be reasonably sure will produce high quality beets and the maximum sugar per acre in all territories and under varying conditions.

It will be readily understood that each area producing sugar beets should have the varieties which, on the average, give the best all round results for that particular area. For example, all the areas in the West subject to curly top disease must choose, first of all, a variety highly resistant to this disease, as this factor of curly top resistance outweighs all other considerations. In other words, this one factor largely governs the sugar production per acre, and other factors such as sugar content and purity are of secondary importance.

In the same way, for the states of Michigan, Ohio, Indiana, and the beet growing sections of Ontario, I would say that the matter of resistance to blight, or leaf spot, largely determines the choice of varieties. The Cercospora disease is sufficiently wide-spread and persistent in these areas so that in any breeding program for the Eastern section, leaf spot resistance must be given first consideration.

In the four states in which the Great Western operates, we have a somewhat different situation in that we have no disease which is uniformly important in all districts. For our areas we need three different varieties, which I am listing in the order of their importance.

1. Our G. W. Yield variety, needed for 60% of our acreage.

2. Our Leaf Spot Resistant variety, needed for 30 to 35% of our acreage.

3. A new variety being developed for resistance to Rhizoctonia, needed for 3 to 5% of our acreage.

At the present time our G. W. Yield variety is the best all round variety for general use in our areas. Where no diseases are involved, it gives the maximum yield of sugar per acre, in the form of a well-shaped root of high purity and good sugar content. It has been tested all the way from the Imperial Valley of California to Michigan and Ontario and under these widely different conditions was outstanding in many cases.

Eastern Colorado and some sections of Nebraska are subject to attacks of leaf spot about one year out of two, on the average, so it is important that we have a resistant variety for these areas. We are rather proud of our new G. W. leaf spot resistant variety, seed of which is now being produced on a large scale. It has very find resistance and is of outstanding performance under leaf spot conditions. We began the breeding of this variety in 1931 but made our big im-

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1/ In Charge of Research, Chief of Exp.Station, and Agronomist, respectively, Great Western Sugar Company.

provement in resistance in the year 1936 when we were able to select strongly resistant individuals in the families previously selected for a fair degree of resistance.

In the sugar beet growing areas east of the Rocky Mountains resistance to leaf spot, Cercospora beticola, offers more promise of early and significant contributions to the successful production of sugar beets than does any other single character subject to breeding control. While certain rather expensive sections of this general area, as, for example, Montana and the San Luis Valley in Colorado, are quite free of this disease, it is generally recognized as a serious limiting factor in production in favorable years over most of the area.

In studies previously reported by LeClerg (4)2/; Gaskill at the 1935 Sugar Beet Round Table meetings at Fort Collins; Brown at the 1938 General meeting of this Society; and by Young, Eskilson and Calland at the 1939 Eastern Regional meeting of this Society; it appears that gains of up to 25% in yield of sugar per acre are not uncommon as a result of protection against leaf spot by spraying or dusting.

Brewbaker and McGreevy(3) reported for the year 1937, a regression of 3.62% in yield and .80% in sugar (in per cent of the Standard variety used in the test, which was very susceptible to leaf spot) for each unit change in leaf spot rating from 0 = none to 10 = very susceptible. Comparable regression figures for the 1938 tests at Fort Morgan were 4.22% for yield and 1.33% for sugar, giving an average for the two years of about 4% for yield and 1% for sugar. The percentage increases for yield and per cent sugar added together approximates the total sugar increase. For an average of the two years this would be about 5%. Under heavy leaf spot conditions, susceptible commercial varieties will differ from the more resistant breeding strains by as many as 6 or 7 units on the resistance scale of 0-10, thus accounting for as much as 30 to 35% difference in total yield of sugar.

Methods Used in Breeding for Leaf Spot Resistance

There are several major lines of approach being followed in breeding for leaf spot resistance by The Great Western Sugar Company, viz.,

1. Intensive family and group breeding. Individuals are selected for freedom from leaf spot under epidemic conditions. These selections are made mostly in the regular breeding strains which are basic to the G. W. commercial variety, although selections are also being made in Cesena and other commercials which show considerable leaf spot resistance but are relatively low yielders, or are otherwise undesirable commercially. These selected individuals are grouped into various combinations of from a few to over 100 roots. Open-pollinated seed, harvested individually, provides the basis for extensive progeny testing in replicated trials.

The purification of resistance has proceeded very rapidly by this method, the process having been accelerated materially through greenhouse groupings, thus completing a generation in one year. These results indicate relative simplicity of inheritance for this character, specific information for which is still unavailable to the industry.

2/ Figures in parenthesis refer to "Literature Cited".

2. Mass selection of a large number of individuals to be increased immediately into basic material for commercial production. This has not been used to any considerable extent since it is much less efficient in the production of a high degree of resistance than the family and group method.

3. First generation crosses between resistant commercials or pedigreed lots from widely different sources. Several such wide crosses have been made looking toward the possibility of hybrid vigor but maintaining the resistance characteristic of the parents.

4. Crosses of G. W. elite stock material with B. maritima, particularly North Sea types which are ordinarily biennials, and other wild relatives followed by successive backcrosses to the commercial parent.

5. Selection in self-fertilized lines or inbreeding through self-pollination. Uniformity for resistance can be obtained more rapidly by the inbreeding mode of attack than by any other but it is accomplished at the sacrifice of the balance of other characters necessary for commercial value, hence the necessity of later testing of various combinations of inbreds to restore this balance.

Results

1937

The first grouping (Group 3642) of quite resistant individuals included 51 roots planted into the greenhouse during the winter 1936-37. Sufficient seed was obtained from only 4 roots to plant in a replicated progeny test. In per cent of the Standard (GW18) these 4 families showed average increases of 10.4% in weight of roots, 4.5% in per cent sugar, and 15.2% in total sugar. The average leaf spot rating was 1.5 for these families and 6.4 for Standard.

1938

Individuals selected in 1937 under leaf spot epidemic conditions were again planted to the greenhouses in the fall with seed being harvested for testing in 1938. In these increases B15 constituted a wide L.S.R. selection (58 roots) from Group 3642, and B17 was planted to 15 roots from Group 3642 and 15 very L.S.R. individuals from Cesena. The briefly summarized results are as follows:

Table 1 - Variety test at Fort Morgan, 1938

Variety	Yield of Roots		Sugar		Total Sugar		App. Pur	Leaf spot
	T. per A.	% of Std.	%	% of Std.	T. per A.	% of Std.		
B17	14.77	105.6	15.92*	116.3	2.354*	123.0*	87.3*	1.4*
B15	15.40*	110.0*	14.86*	108.5*	2.289*	119.6*	85.6*	2.4*
Cesena	13.19	94.3	14.92*	108.9*	1.968	102.8	85.0*	4.0*
U.S. 200 x 215	14.35	102.6	13.61	99.4	1.948	101.8	84.0	6.0*
GW18 (Std.)	13.99	100.0	13.69	100.0	1.914	100.0	83.9	7.6
Dif. for Sig.	.99	7.1	.40	2.9	.149	7.8	1.1	0.5

*Significantly above Standard.

The results show striking increases in yielding ability and quality for the L.S.R. production B17 and B15 as compared with GW18, the European variety Cesena, or the Government production U.S. 200 x 215, which has been released as a resistant variety. These two groupings show extreme resistance to leaf

spot, the ratings for these two groups and the Standard being, respectively, 1.4, 2.4, and 7.6. This difference in leaf spot might account for increases of from 25 to 30% in yield of sugar per acre on the basis of the regression of 5% per unit of leaf spot rating, as previously given in this paper.

There were a number of families in the 1938 test which resulted from grouping of very resistant individuals. Those originating in Group 3711, in which 8 roots out of 15 included in the group produced sufficient seed for replicated trial, showed an average increase of 25.73% of total sugar per acre over the Standard. The comparative ratings for leaf spot were 2.09 for the average of the 8 families and 7.6 for Standard.

1939

This year was unusual in Northern Colorado, the rainfall being about 50% of normal, with leaf spot failing to reach serious epidemic conditions except where artificially stimulated as by overhead irrigation. Approximately 3600 plots were planted in one field nursery of 13½ acres near Fort Morgan, most of which were of some interest for resistance to leaf spot. Of these plots about 1000 should have exhibited extreme resistance. At no time during the season did leaf spot reach sufficient proportions to take notes on its incidence.

All was not lost, however, since the yield results under non-leaf spot conditions provided an opportunity to observe the performance on an extensive scale in the absence of the disease factor. It served also as a caution to extravagant claims for major contributions resulting from a series of flushing victories -- such as sometimes occur in other and possibly even more exciting games such as football.

A broad mass increase (GW1051) of the original leaf spot resistant Group 3642 was tested at 5 locations including 3 in Colorado and 2 in Montana. The average results for all 5 locations in comparison with the regular pedigreed strain of Great Western (GW1053) and the Standard (GW18) are presented as follows:

Table 2 - Results averaged for 5 locations in 1939

Variety	Yield of Roots		Sugar		Total Sugar	
	T. per Acre	% of Std.	%	% of Std.	T. per Acre	% of Std.
GW1051	16.89**	93.80**	16.26**	98.13**	2.743**	92.03**
GW1053	19.11*	107.37*	16.33**	98.50**	3.117*	105.72*
GW18 (Std.)	17.75	100.00	16.57	100.00	2.943	100.00
Diff. for Sig.	.62	3.53	.20	1.26	.108	3.72

* = significantly above and ** = significantly below Standard.

Under the conditions existing for these tests with leaf spot occurring as a very light attack at only the Longmont station, the resistant variety GW1051 appears at some disadvantage with a yield of 92.03% of Standard in total sugar. Applying the regression figure of 5% total sugar for each unit in leaf spot rating, it would require less than 2 units of leaf spot to depress the total sugar yield of Standard below GW1051 and less than 3 units to place GW1051 and GW1053 on a corresponding equal basis. Under leaf spot conditions similar to those existing in 1937 and 1938, GW1051 would be expected to exceed Standard by 10 to 15 per cent, and the susceptible GW1053 by 5 to 10 per cent in total sugar.

Another production from Group 3642 (B40), which originated as the second increase of but two families, was tested at the Longmont and Fort Morgan locations. The results obtained for the original families in 1937 and the first increase (Gr. 3718) in 1938, both under heavy leaf spot epidemic conditions, and the mass increase of Gr. 3718 (B40) are given in per cent of the Standard (GW18) for all characters except leaf spot in Table 3:

Table 3 - Comparison of parental strains with 1st and 2nd increase of very resistant material.

Variety	Year Tested	Yield of Roots	% Sugar	Total Sugar	Leaf spot (a Strain	Standard
Parental strain 15345	1937	119.8	101.5	121.7	1.9	6.4
" " 15369	"	107.7	107.8	116.1	1.1	6.4
1st increase, Gr. 3718	1938	110.2	108.1	119.1	1.6	6.8
2nd increase, B40 (Ave. 2 locations)	1939	90.4	98.4	88.9	.03(b	2.7

a) The comparison for leaf spot is made directly in terms of the 0-10 scale of resistance to susceptibility.
b) For Longmont only, no leaf spot at Fort Morgan.

The apparent drop in yield from the parental strains and the first increase to the second increase is greater than would be expected based on the prediction of 5% loss for each increase of one unit of leaf spot. It is quite probable that the narrow origin of B40 may be responsible for some of this loss. Under leaf spot conditions similar to those existing in 1937 and 1938, B40 should yield upwards of 10 to 15 per cent increase over Standard on the basis of this prediction.

Two broad increases of very resistant selections from Group 3642 have been made: namely, B15, a greenhouse increase (See Table 1) and B42, a field grouping. The roots were selected similarly to those used for B40 (See Table 3), except that only 2 families are represented in B40 and 34 families in both B15 and B42. The results obtained at Fort Morgan for B15 for both 1938 and 1939, and B42 for 1939 are summarized in Table 4:

Table 4 - Results obtained for two resistant selections from Group 3642 as expressed in % of Standard.

Variety	Year	Yield of roots	% Sugar	Total Sugar
B15	1938	110.0	108.5	119.6
B15	1939	97.7	97.3	95.0
B42	1939	97.3	97.6	94.9

In 1938 leaf spot was rated at 2.4 on B15 and 7.6 on Standard. This difference would be expected to result in 25% difference in total sugar yield. There was an actual reduction of 24.6% in total sugar in 1939 as compared with the 1938 results for B15 in per cent of Standard, which closely approaches the expected on the basis of the prediction figure of 5% for each unit of leaf spot, as given above. The two increases B15 and B42 are approximately equal in every respect under non-leafspot conditions.

Varietal crosses for leaf spot resistance

There was some indication of hybrid vigor in a relatively wide cross, Cesena x Group 3642, in the above 1938 tests at Fort Morgan. Group 3642 was also crossed with Cesena and the two U. S. leaf spot resistant releases U. S. 217 and U. S. 200 x 215. These crosses were made by merely grouping roots of the two parents, hence by random mating 50% of sib-pollination was possible. The test was conducted in this manner in order to determine the commercial possibility of such an incomplete hybrid, since complete hybridization as in corn is impractical for sugar beets except through the possible employment of one male sterile parent. The crosses were planted at both Longmont and Fort Morgan, the results being summarized in Table 5:

Table 5 - Performance of wide crosses and certain of the parents in per cent of Standard, 1939.

Variety	Yield of Roots	% Sugar	Total Sugar
B36 and 37 - US 217 x Gr.3642, F_1	95.37	100.09	95.45
B38 and 39 - (US200x215) x Gr.3642, F_1	99.20	99.25	98.45
B35 - Cesena x Gr. 3642, F_1 (a	91.30	102.02	93.14
B70 - Cesena x Gr. 3642, F_2 (b	83.37	102.65	85.58
A8 - Commercial Cesena (c	73.87	99.12	73.22
A36 - U.S. 200 x 215	98.12	98.24	96.37
GW1051 (Gr. 3642)	98.26	97.55	95.84
Diff. for Significance	6.33	4.21	8.44

a) Not the same origin as B70, the roots used for B35 being more carefully selected for leaf spot resistance, size and shape.
b) Similar to B17, see Table 1.
c) Results for Longmont only, all others are averages for Longmont and Fort Morgan.

The yield and per cent sugar for the cross (U.S. 200x215) x Gr. 3642 are both slightly higher than either parent, the difference, however, being statistically insignificant.

Cesena was tested only at Longmont, the results at this Station for the two parents and the F_1 hybrid, Cesena x Gr. 3642, being presented in Table 6:

Table 6 - Performance of parents and F_1 hybrid expressed in per cent of Standard

Variety	Yield of Roots	% Sugar	Total Sugar
GW1051 (Gr. 3642)	93.50	97.42	91.08
Cesena	73.87	99.12	73.22
Ave. of parents	83.69	98.27	82.15
F_1 hybrid	89.10	101.56	90.50
Increase F_1 over Ave. of parents (a	5.41 (3.58)(a)	3.29	8.35(6.54)(a)
Diff. for Sig.	5.41	3.60	7.21

a) Recorded yield for one plot of Cesena was so low as to be of questionable accuracy. Figures in parenthesis indicate the results obtained when a calculated plot value was used in place of the recorded one.

The F_1 hybrid is above the average of the two parents in yield of roots, total sugar and per cent sugar, the difference approaching significance. These results suggest heterosis or hybrid vigor for this varietal cross. The F_1 would be expected to exhibit greater resistance to leaf spot than the GW1051 parent, and in a leaf spot year this fact alone would tend to give the hybrid a real advantage.

Selection in self-fertilized lines

The work on inbreeding is necessarily based on a long time program looking toward ultimate improvement in several characters. Since the parentage is under complete control it is possible to produce lines pure for certain characters and use those for rebuilding a variety based on certain specifications. By no other method of breeding will this control be possible. In the Kodachrome slides presented some of the characteristics of inbred lines are shown.

Other Characters of Interest in Improvement Through Breeding

Recent studies have shown certain characters to be of more or less immediate interest from the standpoint of breeding for improvement in the sugar beet. Previously no particular emphasis had been placed on these so far as our breeding work was concerned. The evidence as to possibilities will be briefly presented.

Cold resistance, strength of seed stalk, and seed production

In connection with overwintering increases of Great Western lots severe winter killing was experienced during the winter of 1936-37. Not more than 2% of the entire population survived in two fields. Plants which were not damaged were grouped for increase, and for progeny tests in 1937-38 in comparison with the parental stock. Of the 137 such families tested 104 or 75.9% showed less than 5% winter killing, while the 20 plots of parental check material ranged from 5 to 20% with an average 11.1% killing.

Further evidence of the increase in winter hardiness accomplished by this one selection may be seen from Table 7 in which varieties 4 and 5 are the mass collections of seed from apparent cold resistant individuals selected in the spring of 1937 as described above.

Table 7 - Results obtained for overwintering test of varieties at Windsor.

Variety	% Winter Killing 3/18/38	Lbs. Clean Seed per Acre
1 - U. S. 12	10.4	1938
2 - European Commercial	13.2	1215
3 - Parent of 3 and 4	12.4	1390
4 - Seed mixture 100 plants	4.4	1407
5 - " " 25 "	3.4	1760
F	3.86*	2.08

* = significant difference between varieties.

Varieties 4 and 5 showed significantly less winter killing than varieties 1, 2, and 3, indicating further evidence of the heritability of cold resistance.

Strength of seed stalk

In the strain test discussed under "cold resistance" there appeared very striking differences in strength of seed stalk just previous to harvest. These were rated on the basis of 1 - strong to 5 - weak, with results as follows:

Strength Rating	No. Families in each class	No. parental plots in each class
1	8	0
2	47	6
3	54	7
4	23	6
5	4	1
Total	136	20

These results show a very wide range for strength of stalk.

Yield of seed

Yields of clean seed per 30 ft. of row obtained for the strains included in the test discussed under "cold resistance" are distributed in classes as follows:

Oz. Seed	No. Families in each class	No. parental plots in each class
16-20	1	
21-25	4	2
26-30	9	8
31-35	11	5
36-40	26	3
41-45	34	1
46-50	32	1
51-55	8	
56-60	7	
61-65	2	
66-70	2	
Total	136	20

Nineteen families ranged above the highest yielding parental plot indicating possibilities of material increase in seed yielding ability through breeding methods.

Correlation of strength of seed stalk and yield of seed

In order to determine whether the apparent weakness of the seed stalk was due to the weight of seed which it carried, the correlation was calculated, with an obtained r value of -.1280, which proved to be not significant. Hence, these characters would appear to be independent in inheritance, and certainly worth considering in a breeding program.

Rhizoctonia resistance

Conservative estimates based on studies conducted during 1938 and 1939 show that diseases caused a loss of at least 2000 tons of beets in the Great Western Sugar Company territory during those years. These same studies show that at least 35.75%, or 715 tons, of this loss was due to Rhizoctonia root-rot.

This loss is not very impressive when thought of as the result of Rhizoctonia root-rot over a period of two years and over an area of more than 400,000 acres of beets. However, there are local areas where the losses reach serious proportions. Each year there are individual fields where the damage results in serious financial losses to the grower.

The need for maintaining sugar beet acreages in badly affected areas and on farms subject to serious damage seems to justify an attempt to produce a Rhizoctonia resistant strain of sugar beets. The Great Western Sugar Company's attempt to produce such a strain of sugar beets is still in its infancy.

In this work the possibility that beets resistant to Rhizoctonia in the seedling stage (black-root) may not be resistant to the summer root-rot and vice versa has not been considered. This paper deals with the summer form of root-rot and the possibility of producing strains of sugar beets resistant to it.

The first selection was made the fall of 1937 from a field that had grown potatoes in 1936. The loss on the entire area was in excess of 75%. On that part where the selections were made, and this covered a large part of the field, not over 10% of the beets remained alive at the time the selection was made.

In making the selection only healthy beets completely surrounded by dead ones for considerable distance were chosen. These selected roots were stored in a pit silo until the spring of 1938.

As soon as conditions permitted 49 of the best of the selected roots were set out in an isolated location. Fourty-four of these produced seed. The seed of each individual root was harvested separately.

The spring of 1939 a mixture composed of aliquot parts of the seed of each of the individuals harvested in 1938 was planted. The field selected for this planting grew sugar beets in 1938. By harvest time that year, the crop was almost entirely destroyed by Rhizoctonia root-rot.

The planting was so planned that 3 plots of seed from the selected roots alternated with two plots of Great Western Home grown commercial seed. This arrangement gave 5 plats; Nos. 1, 3, and 5 planted with selected seed and 2 and 4 with G. W. Commercial-39.

There was no visible differences in the germination or thinned stands. Actual determinations of these stands were not made. Immediately after thinning beets began to die. This loss of plants continued throughout the season and was still in progress at the time the final observation was made which was just a few days before harvest.

The final observation was made by laying out a strip 100 ft. wide across the field at right angles to the rows. The number of living beets in 3 rows (300 ft. of row) was determined in each of the 5 plots.

Rhizoctonia had destroyed many plants in all plots so that at the time this observation was made the stands were 22.5% and 44.3%, respectively, for the plots planted with commercial and selected seed.

The number of plants in 300 ft. of row for each of the plots is given in the following table:

	Type of Seed				
	Select.	Commercial	Select.	Commercial	Select.
No. Plants	144	61	122	74	133

The mean for the selected seed was 133 living plants per 300 ft. of row and 67 for a corresponding length of row of the commercial seed. The selected seed had a stand nearly twice (198.5%) that of the beets grown from the commercial seed at harvest.

The commercial value of the selected strain was not determined. The principal object of the 1939 study was to learn if selections such as were made in 1937 would result in the segregation of strains tolerant or resistant to the summer form of Rhizoctonia root-rot.

The observations recorded above suggest the existence of Rhizoctonia resistant strains in our present commercial seeds and the possibility of developing such strains through the medium of selection.

Root-knot nematode resistance

During the growing seasons of 1937-38 and 39, 25791 beet fields were examined for sugar beet nematode. At the same time root-knot nematode infestations were noted and reported. It is probable that a small number of fields were examined more than once during the three years. However, this number would be so small that it may be ignored. Of the 25791 fields examined, 6.11% were found infested with root-knot nematode.

The total loss due to root-knot cannot be estimated. However, every year many fields are seriously damaged even to the point of a total loss. These losses are more or less confined to certain portions of Great Western Sugar Company territory. Because of this localization of the loss and the difficulty attending control by field practice and our inability to prevent the spread of this pest, it seems best to give some attention to the possibility of producing resistant or tolerant strains of sugar beets.

Steiner (5) distinguishes between host resistance to nematode attack and host tolerance. Plants that actually resist the entrance of nematodes, he considers resistant. Hosts that have the ability of developing with little signs of distress in spite of presence of root-knot galls, he calls tolerant.

If the plant breeder accepts Steiner's definitions of resistance and tolerance it is important that he know what plant characters are associated with resistance and tolerance.

Artzberger (1) has attempted to account for root-knot resistance by comparing the morphology of the roots of two resistant and two susceptible cow peas. The resistant varieties (Iron and Brabham) had roots that were better guarded by protective tissue than the two susceptible varieties (Whippoorwill and early Buff). In the resistant varieties the cork layer was better developed, had fewer broken areas and the cell walls were more suberized. The mechanical tissue was more uniformly distributed in the resistant varieties.

Barrons (2) defines root-knot resistance as "any perceptible ability on the part of a plant to grow in nematode-infested soil without the formation of root-knot galls". This conception entirely disregards Steiner's host tolerance and host resistance. He found that there was no significant difference in the rate of entry in the most resistant and susceptible plants in the seedling stage. He also observed that the root-knot galls on Henderson Bush Lima and Hopi 155 Lima beans were the same size in the seedling stage but that later they are much smaller on the roots of Hopi 155. He concludes that this indicates the development of some substance within the root of the variety that retarded the development of galls.

Nematologists seem to be agreed that the root-knot nematode feeds upon the contents of the giant cells which are apparently induced by salivary secretions of the nematode.

Barrons advances this speculative hypothesis, "that resistance may be due to certain chemicals within the roots of resistant plants that counteract or neutralize the giant-cell-inducing effect of the salivary secretions of the nematode".

Work of the Great Western Sugar Research Department began with a selection of seed from sugar beets grown in a field in Arizona. These plants were located in areas where all surrounding plants killed, or were so stunted by root-knot that practically no seed was produced. The seed thus selected was planted on a field so heavily infested with root-knot nematodes that two plantings of sugar beets were completely destroyed in 1938. Several commercial strains were also planted in this field.

The nematode infestation in 1939 was not nearly as severe as in 1938. It was also rather irregularly distributed which made it difficult to determine the effect, if any, of the selection on resistance.

Just before the field was harvested 4 plots each containing 66 ft. of row from the selected strain and each of the two adjoining commercial strains were selected at random, and the number of beets in each plot determined. Weights and sugar contents were not compared since they would be of no value in determining relative resistance to nematode in this instance.

The number of beets living at harvest was smaller in the case of both commercial strains than in the selected one by nearly 10%. An examination of the roots revealed the fact that certain individuals grew to good size and form even though surrounded by roots very seriously affected by root-knot. It is hardly probable that such roots were escapes. If they were not, then we must assume that they are either resistant or tolerant to root-knot.

Further study is necessary before it can be said that resistance or tolerance to root-knot nematodes exists in sugar beets.

Future Breeding Problems

Among future refinements in the breeding program of The Great Western Sugar Company are the following:

1. Further improvement in the purity of beets. Up to the present time we have made a gain of about 1.5 points in purity over foreign varieties. Careful analysis of our extraction figures at the factories shows that this increase in purity with the sugar content which accompanies it, means an additional recovery of about 7 lbs. more granulated per ton of beets, a goal well worth striving for. In years of severe leaf spot this increase in purity will be still greater because of the serious effect the disease has on purity of beets.

2. The introduction of more vigor and disease resistance into our present commercial varieties by means of genes coming from Beta maritima. This work is now far along and we already have hybrid varieties which are about equal to good commercial varieties. This phase of our work was discussed more fully in the Genetic Section of this meeting.

3. The possible development of a variety sufficiently flexible to meet all conditions of 80% or more of our acreage. This may or may not be attainable, but offers an interesting and exciting goal for any breeding program.

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PRINCIPAL FEATURES OF THE SEED ACCESSION SYSTEM IN USE BY THE GREAT WESTERN SUGAR COMPANY

(Demonstration Paper)

By H. E. Brewbaker 1/

The system for numbering and recording seed lots was devised to provide a simple and efficient means of identification, showing the origin, description, year produced, deductions, and status of any seed lot in storage at any time after it is first recorded. The present system was recently adopted after it became evident that the system previously used was inadequate to meet the needs of rapidly growing complexity incident to the development of the domestic seed industry and of more extensive breeding stimulated by that development.

It would probably be useless to attempt to standardize numbering and recording systems. Many different types are in use and there is little information available in published form. Harrington 2/ reviewed methods used by cereal breeders. The method adopted, as described below, includes certain features of the Minnesota system described by Harrington.

In general, the following groups or categories will cover all phases:

I. Seed from individual either open or self-pollinated, crosses of individuals or mixtures of seed from two or more individuals to be used in progeny tests in the same manner as seed from individuals.

II. Mixtures from more than one individual either as a group or a cross, primarily for breeding or testing purposes.

III. Pedigreed lots for immediate production of commercial seed.

IV. All Great Western commercial seed productions.

V. New introductions. Individuals, small lots for breeding purposes, and commercial varieties not produced for or by the G. W. Sugar Co.

In more detail, the qualifications for each group are as follows:

I. Seed from individuals either open or self-pollinated, or crosses of individuals. Will also include mixtures of seed from two or more individuals to be used in progeny tests in a similar manner to seed from individuals. Such mixtures will carry the prefix "X". The seed of an individual will carry the mother number, which continued from 1 to infinity without break for the year. If self-pollinated the family number will carry the prefix "S". If a cross it will be written in either of two ways as follows: $\frac{15335}{15432}$ or 15335 x 15342, the female parent being the numerator when written as a fraction or first number when written with a multiple sign; and the generation should be given as F_1, F_2, etc., immediately after the number in either case, e. g., $\frac{15335}{15342}$ F_1 or 15335 x 15342 F_1.

1/ Agronomist, Great Western Sugar Company.

2/ Harrington, J. B. Methods of keeping records of cereal breeding investigations. West Can. Soc. Agron. Proc. 3rd meeting, 1922.

One accession loose leaf book is devoted entirely to Group I seed. Mixtures of 2 or more individuals to be used as an individual in breeding strain tests will be entered at the bottom of each breeding group.

The breeding groups are numbered separately for each year, the scheme used being convenient but nonessential to the seed recording method. The group numbers for each year begin at 1 with a prefix consisting of the last two figures in the year, e. g., 391 was group 1 in the year 1939.

II. Mixtures from more than one individual, either as a mass grouping or a cross, primarily for breeding purposes or observation tests. These lots will carry the prefix "B" to a separate series of numbers 1 to infinity which are carried in Section 1 3/ of a loose leaf accession book (End Lock Style).

III. Foundation or pedigreed lots for production of commercial seed the following generation. Only those productions by the G. W. Sugar Company will be included in this category. The lots will carry the prefix "GW". Numbers GW1001 to infinity will be used for pedigreed lots. Entries are made in Section 2 of the same accession book used for Group II seed.

IV. All productions of commercial seed made by or for the G. W. Sugar Company. Lots will carry the prefix "GW", numbers 1 to 1000 being reserved in Section 3 of the same accession book used for Groups II and III seed. Mass increases of commercial seed made by the G. W. Sugar Company, without selection, will carry the same GW number. When some selection, either natural or artificial, has been a factor in any such commercial increase, a new GW number is assigned.

V. New introductions. Individuals, small lots for breeding or testing purposes and commercial varieties not produced for or by the G. W. Sugar Company. All new introductions will be listed in the accession record referred to under II and III, with numbers "A" 1 to 1000 reserved for the commercial lots and with other lots being numbered A1001 to infinity.

Miscellaneous Considerations

1. Tags on lots for Group I will carry "Beet No." and "Breeding Group", and Groups II, III, IV, and V the "Accession number", "Lot" (when one is assigned) "Year Grown" and "Place". The variety name in case of commercials may be carried.

2. All additions and deductions for Groups II, III, IV, and V are recorded immediately in longhand in a separate bound entry book, numbers being assigned at this time for all new additions. Transfers are typed into the accession records at the beginning of each month.

3. A chronological index is used to provide easy reference to all lots in the accession book.

4. When pedigreed or other lots of seed are sent out from the Station for commercial seed production, they bear their own accession number, but a new "GW" commercial number is assigned at this time.

3/ Sections 1 to 5 referred to are separate sections of the loose leaf book used for all classes of seed other than I.

5. All seed lots are given a "class" designation (A,B,C, or D) in the accession records for insurance purposes, since each of these classes is valued at a different figure.

CLASS "A" SEED (INDIVIDUALS - GROUP I)
SAMPLE PAGE FOR ORIGINAL ENTRY AND CALCULATION BY THE PERSON CONDUCTING THE GERMINATION

(Longhand entry)

Beet No.	Origin M. No.	Wt. Seed Oz.	Balls Per Oz.	% Germ.	Germ. Balls Per Oz.	Total Germ. Seed Balls	Possible Ft. of Row (a)	
							Tot.	Per Oz.
18579	16423	10.5	1850	94	1739	18120	1510	144
Etc.								

a) Based on 12 germinating seed balls per foot of row.

CLASS "A" SEED (INDIVIDUALS - GROUP I)
SAMPLE PAGE FOR FINAL ENTRY IN ACCESSION RECORD

Beet No.	Origin M. No.	Oz. Seed	% Germ.	Ft. Row Per Oz.	No. S Seed	Inventory					
						Date	Oz.	Date	Oz.	Date	Oz.
18579	16423	10.5	94	144	75	6/39	6.5				

ACCESSION RECORD

	Acc. No.	Lot	Class	Stored	% Germ	No. Balls per lb.	Date	Amount of Seed Lbs. Rec'd	Used	Inv.	Origin, Description and Source of Seed and Purpose for which used
G.W. Commercials (Group IV) SAMPLE PAGE	GW25	1K	D	"B"	86	27190	9/35	86.0			Leaf Spot resistant type produced at Windsor, 1935. Mass increase of GW1004.
							4/36		4.0	82.0	For variety tests.
							4/39		1.75	80.25	For variety tests.
							8/39		1.50	78.75	To Windsor for overwinter stocks
G.W. Pedigreed lots (Group III) SAMPLE PAGE	GW1004		C	"B"	85	28950	8/32	531.0			P-2LSR-1932-W. Select roots from families 10362, 10364, 10683, 10693, 11067, 11176, 11219, 11222, 11226, 11227, 11228, 11250, 11254, 11259, 11266, 11272, 11276, 11281, 11283, 11309, 11316, 11325, 11349, 11366, 11369, 11381, 11395. Stecklings from families 10014 R, 10017 R, 10369, 10544, 10545, 10553, 10655, 10658, 10661, 10666, 10667, 10675, 10756, Ped. 9154, Ped. 9542. Groups 284, 291, 292, 301, 302, 303, 304, 271, 284, 286, 291. P-9154 and 9542 were planted as family groups on the Donovan Tract in 1929 in connection with a large number of selected mothers from the 1928 breeding strain test with which they crossed. Seed of 9154 and 9542 were harvested separately. 9154-Gr.212; 9542-Gr.231.
							4/34		517.5	13.5	For commercial increase
							4/39		2.0	11.5	For variety tests
Commercial Introductions (Group V) SAMPLE PAGE	A36		D	"B"	73	33140	4/39	50.0			U.S. 200x215, commercial. Received from Ft. Morgan. Inbreds 200 and 215 were used as 25:75 seed mixture, respectively, to produce this variety. See "Report of 1938 tests of U.S. 200x215 and allied varieties." U.S.D.A.
							4/39		15.0	35.0	For variety tests

STUDIES ON SOME F_1 SUGAR BEET HYBRIDS
(Demonstration Paper)

Frank F. Lynes and C. E. Cormany (1

Considerable breeding work has been conducted on sugar beets both in foreign countries and in the United States. Much valuable information has been obtained as a result of this work. As a direct result of the work in the United States there are on the market today a number of American varieties of sugar beets.

The commercial varieties of sugar beet seed available for planting by the beet grower are largely hybrids. Thus in the development of new varieties of sugar beets hybridization is usually employed at some point. The point where hybridization is employed is determined by the material being developed. The formation of a hybrid by cross pollination of two strains may be the initial step in the development of a new variety or it may be the final step in the breeding process giving rise to F_1 commercial seed for planting by the grower.

In as much as hybridization occupies a prominent position in breeding programs on sugar beet improvement, a study of F_1 hybrids should add materially to our knowledge of how we might benefit the most from this process.

When hybridization is employed in the early stages of the development of a new variety for purposes of combining desirable characters, the plant breeder has available only a few selected roots of his strains to work with. In hybridizing two strains, the usual method employed is to plant roots of the two strains in close proximity to each other and allow them to cross pollinate since the sugar beet is naturally a cross pollinated plant. The sugar beet flower is a perfect flower having both staminate and pistillate parts. The question arises as to whether or not seed harvested from Strain A assumed to be pollinated by Strain B will give rise to a progeny materially different from that produced by the seed harvested from Strain B assumed to be pollinated by Strain A. Evidence obtained in our 1939 Breeding Strain trials of the progeny of F_1 hybrids at Sheridan, Wyoming, indicates that the seed borne by the mother parents may differ materially.

In the production of a new variety, consideration should be given to the foliage characteristics, a variety having large, upright, broad foliage appearing to be desired by our growers. Inasmuch as contrasts of these foliage characters appeared in the parent material of the hybrids, notations were made of the foliage character of the progeny of the F_1 hybrid. The parents of the hybrids studied were selected roots of commercially available varieties which have proven their ability to porform satisfactorily commercially, and were in general use in the various sugar beet territories in 1938. The hybrids were formed by the bagging method whereby a branch of each of the two parents was confined in a 6# kraft paper bag and the seed was harvested separately from each branch. Thirty-nine hybrids involved the contrasting traits of large and

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1) Assistant Agronomist and Chief Agronomist, respectively, Holly Sugar Corporation.

small top. Twenty-six of these hybrids exhibited the trait of the pollen parent, ten having large top and sixteen having small top; and thirteen of these hybrids exhibited trait of the mother parent, six having large top and seven having small top. Seven hybrids involved the contrasting trait of broad and narrow leaf blades. Six of these hybrids exhibited the trait of the pollen parent, two having broad and four having narrow leaf blades; and one of the hybrids exhibited the trait of the mother parent, broad leaf blade. Seven hybrids involved the contrasting traits of upright and flat foliage. Five of these hybrids exhibited the trait of the pollen parent, three having upright and two having flat foliage; and two of these hybrids exhibited the trait of the mother parent, both upright foliage.

These limited data indicate that the appearance of these contrasted foliage characters in the F_1 progeny of a cross may be dependent upon their introduction by the pollen parent.

Other desirable characters are also incorporated through hybridization. All hybrids in our breeding strains were evaluated on the basis of visual appearance as compared with our commercial check, taking into consideration size and shape of roots, together with size and shape of crown. The progeny of those hybrids which appeared to be equal to or better than the progeny of the commercial check were designated as good hybrids, those being inferior to the check were designated as being poor hybrids. This study involved 808 hybrids formed by harvesting 404 single crosses separately by mother parent as previously explained. The following table gives the results of the crosses involving one parent of the intermediate type and serves as a cross section of the data obtained. The term "Percent Good F_1 Hybrids" refers to the above mentioned classification whereby the entire progeny of a mother parent was considered as being good or poor.

TABLE 1

CLASSIFICATION OF THE PROGENY OF F_1 HYBRID SEED RESULTING FROM CROSSES OF 1 VARIETY OF INTERMEDIATE TYPE WITH SIX OTHER VARIETIES

Percent Good F_1 Hybrids When Parent Used As:			
♀	♂	Difference	Type Crossed With
0	100	100	Intermediate
100	0	100	Sugar
0	100	100	Tonnage
100	100	0	Intermediate
0	100	100	Tonnage
0	100	100	Intermediate
Average Difference		83%	(6 Varieties – 5 Types)

These data emphasize the differences which may be obtained by the use of selected roots of commercial varieties as male and female parents of a single cross, and show an average difference due to the use of this variety as the pollen or mother parent, of 83%.

As the number of individuals entering into the crosses is increased, the contrast between the use of the individual plant as the male or female parent is minimized by the compensating effect of averaging the results. This is illustrated in the following data where the results of all crosses between two varieties are averaged for one parent of the intermediate type.

TABLE II
CLASSIFICATION OF THE AVERAGES OF THE PROGENY OF F_1 HYBRID SEED RESULTING FROM CROSSES OF 1 VARIETY OF INTERMEDIATE TYPE WITH 11 OTHER VARIETIES

No. of Crosses	Ave. % Good F_1 Hybrids When Parent Used As: ♀	♂	Difference	Type Crossed With
2	100	0	100	Intermediate
16	86	67	19	Sugar
26	67	79	12	Tonnage
27	64	77	13	Tonnage
8	100	75	25	Intermediate
6	100	100	0	Intermediate
3	50	100	50	Intermediate
9	75	40	35	Intermediate
3	100	50	50	Tonnage
4	100	50	50	Intermediate
2	100	100	0	Sugar
Total 106	942	738	354	(11 Varieties - 3 Types)
Average	86	67	32	

Increase in percent good hybrids = 86 - 67 ÷ 67 = 28%.

The data presented in Table I and II show a reduction in the average difference from 83% when based on individuals to 32% when based on the averages of the variety crosses. For the particular variety, considered in Table II, difference between averages of the parent effect of all 106 crosses show an increase of 28% in good hybrids when the variety is used as the female parent as compared to its use as the male parent. These results are typical of the results where the data are assembled by varieties. Due to the volume of the data collected it is not presented at this time, but they show that the 35 varieties studied varied from 0 to 203% increase due to parent use. The average percent increase due to parent use for the 35 varieties was 45%. Some of the varieties had a greater percent of good F_1 hybrids when used as the female parent and others as the male parent, whereas other varieties showed no differences due to parent effect. The average percent good F_1 hybrids for all varieties when used as the female parent was 74, and when used as the male parent 75, which shows lack of consistant influence of either male or female parent. Fifty-seven percent of all hybrids tested showed a variation in the progeny due to the use of the variety as the male or female parent.

Compilation of the data by types, shows considerable variation indicating that the variation between varieties is greater than the variation between types. In general, the data indicate that better yielding hybrids will be obtained, when crossing two types, by using the heavier yielding of the two types as the mother parent as illustrated by the following data.

TABLE III
CLASSIFICATION OF THE AVERAGES OF THE PROGENY OF F_1 HYBRID SEED RESULTING FROM CROSSES OF TYPES

Parent Type	No. Crosses	Ave. % Good F_1 Hybrids When Parent Used As: ♀	♂	Percent Increase due to parent use:	Type Crossed With
Inter.	33	73	46	59	Sugar
Tonnage	31	73	60	22	Sugar
Tonnage	132	73	66	11	Intermediate

In addition to the production of hybrid seed by the bagging method from selected roots where limited amounts of seed are obtained, there is also the method of producing hybrid seed in quantity by planting blended seed of parent varieties, and obtaining F_1 hybrid seed by natural crossing of the entire progeny the following year. This seed is harvested in bulk irrespective of parent plant since it is the product of a large group cross of unselected material. The blend of seed used for such plantings is known as a mechanical mixture and the F_1 seed resulting therefrom is referred to as a genetic mixture.

In connection with the production of genetic mixtures the question has been raised as to what criterion will give us a fair estimate of the performance of these genetic mixtures prior to production of the seed and subsequent agronomic evaluation. The following study was undertaken to determine whether the arithmetic average of the performance of the parent forms would serve as an index to the performance of their mechanical mixtures or their genetic mixtures.

The following table presents data taken from variety tests conducted at Sheridan, Wyoming, during the seasons of 1938 and 1939. The tests were of the Quasi-Factorial design having 91 varieties with ten replications in 1938 and 144 varieties with six replications in 1939. The data are based on total plat yields. The parent forms consist of Extreme Sugar, Sugar, Intermediate, Tonnage, and Extreme Tonnage types of unselected commercially available varieties. The data involve mixtures of equal and unequal proportions but do not include extreme proportions such as 95 percent extreme sugar and 5 percent extreme tonnage mixtures.

COMPARISON OF GENETIC MIXTURES, MECHANICAL MIXTURES, AND THE WEIGHTED AVERAGE OF THE PARENT FORMS WITH THE ARITHMETIC AVERAGE OF THE PARENT FORMS

All results are expressed as percent of the commercial check

Mixture	Year	% Sucrose				Tons Per Acre				Lbs. Gross Sugar/Acre				% Stand			
		Arith. Ave.	Wtd. Ave.	Mech. Mix	Gen. Mix	Arith. Ave.	Wtd. Ave.	Mech. Mix	Gen. Mix	Arith. Ave.	Wtd. Ave.	Mech. Mix	Gen. Mix	Arith. Ave.	Wtd. Ave.	Mech. Mix	Gen. Mix.
1 - 10 Varieties	1938	100	100	-	98	96	98	-	91	96	97	-	89	99	100	-	102
	1939	100	100	100	99	107	108	104	99	106	107	104	98	108	110	110	107
2 - 10 Varieties	1938	100	100	-	-	98	98	-	-	99	98	-	-	100	99	-	-
	1939	100	100	98	98	107	106	114	97	107	105	111	95	107	105	101	100
3 - 7 Varieties	1938	100	-	-	99	99	-	-	97	99	-	-	96	101	-	-	95
	1939	100	-	98	100	107	-	95	105	106	-	93	104	108	-	101	100
4 - 5 Varieties	1938	97	-	-	99	104*	-	-	94	101	-	-	93	99	-	-	90
	1939	98	-	100	99	107	-	109	103	105	-	108	102	108	-	95	100
5 - 5 Varieties	1938	99	98	-	-	101	103	-	-	100	100	-	-	102	102	-	-
	1939	99	98	98	-	103	105	102	-	102	103	100	-	104	107	101	-
6 - 4 Varieties	1939	98	-	98	-	105	-	102	-	103	-	99	-	105	-	95	-
7 - 4 Varieties	1939	98	-	98	-	97	-	117*	-	94	-	114*	-	104	-	105	-
8 - 4 Varieties	1938	97	97	-	-	104	105	-	-	101	101	-	-	98	98	-	-
	1939	96	96	99*	-	106	106	116	-	102	102	115	-	105	105	108	-
9 - 4 Varieties	1939	96	-	98	-	103	-	114	-	98	-	111	-	104	-	111	-
10 - 4 Varieties	1939	98	-	97	-	106	-	110	-	103	-	106	-	107	-	101	-
11 - 2 Varieties	1938	96	96	95	-	103	104	111	-	100	100	105	-	102	102	105	-
	1939	98	97	96	-	104	103	110	-	102	100	105	-	105	105	108	-

Differences for significance for odds of 19:1 for 1938 and 1939 respectively are: Percent Sucrose: 4 and 3; Tons Per Acre: 9 and 19; Pounds Gross Sugar Per Acre: 9 and 20; Percent Stand: 10 and 15.

*Significantly superior.

PERCENTAGE COMPOSITION AND TYPES

No.	Varieties	Percentage Composition
1	Unequal Parts:	32 - 10 - 10 - 9 - 9 - 9 - 7 - 7 - 5 - 2
	*Types:	T - I - I - ES - I - ET - ES - T - I - I
2	Unequal Parts:	16 - 16 - 16 - 14 - 11 - 6 - 6 - 6 - 6 - 3
	Types:	T - I - I - ES - S - T - I - I - ES - I
3	Equal Parts:	15 - 15 - 15 - 15 - 15 - 15 - 15
	Types:	T - T - S - I - ES - S - ET
4	Equal Parts:	20 - 20 - 20 - 20 - 20
	Types:	T - T - I - I - I
5	Unequal Parts:	30 - 30 - 20 - 10 - 10
	Types:	T - ET - I - S - I
6	Equal Parts:	25 - 25 - 25 - 25
	Types:	T - T - I - I
7	Equal Parts:	25 - 25 - 25 - 25
	Types:	T - I - I - T
8	Unequal Parts:	27 - 27 - 26 - 20
	Types:	ET - I - T - I
9	Equal Parts:	25 - 25 - 25 - 25
	Types:	T - I - I - S
10	Equal Parts:	25 - 25 - 25 - 25
	Types:	T - I - I - I
11	Unequal Parts:	60 - 40
	Types:	ET - I

*Types: ES = Extreme Sugar; S = Sugar; I = Intermediate; T = Tonnage; ET = Extreme Tonnage.

Examination of the data shows that only four comparisons out of the hundred and sixty-eight exhibit significant differences. The arithmetic and weighted averages of the parent forms of varieties used in unequal proportions in mechanical and genetic mixtures, do not differ significantly. The arithmetic average of the parent forms and the mechanical mixtures differ significantly in only three of the forty-eight comparisons. The arithmetic average of the parent forms and the genetic mixtures differ significantly in only one of the twenty-eight comparisons.

The data show that for the mixtures used in this study, the arithmetic average of the performance of the parent forms serves as an index to the performance of mechanical mixtures or genetic mixtures of commercial varieties whether proprotioned equally or unequally.

SUMMARY

The data presented based on selected roots of commercial varieties show that the appearance of some foliage characters in the progeny of the F_1 hybrid of single crosses of such roots may be dependent upon their introduction by the pollen parent. Other data based on 808 crosses give differences in percentage of good F_1 hybrids depending upon whether the variety was used as the male or female parent. The average difference in good hybrids for all 35 varieties studied was 45%. The data indicate that better yielding hybrids of the nature studied may be obtained, when crossing two types, harvesting the seed separately by parent, by using the heavier yielding of the two types as the female parent.

Data presented on the performance of certain genetic mixtures produced from quantities of mechanical mixtures of seed of commercial varieties show that the arithmetic average of the performance of their parent forms serves as an index to the performance of such genetic mixtures.

FURTHER STUDIES OF SUGAR-BEET SEED BALL EXTRACTS WITH SPECIAL REFERENCE TO THE TOXICITY OF HYDROLYZED AMMONIA
(Demonstration Paper)

By Myron Stout and Bion Tolman, Division of Sugar Plant Investigations, Bureau of Plant Industry, United States Department of Agriculture

The presence of water soluble substances in sugar-beet seed balls which had a toxic effect on the germination of sugar-beet seed was reported in a paper presented at the 1938 meeting of the American Society of Sugar Beet Technologists.

The present paper is an evaluation of the effect of osmotic pressure and hydrolyzed free ammonia on the germination of sugar beet and certain other seeds. There was a marked differential tolerance of various seeds to osmotic pressure. It was evident, however, that even with seeds most sensitive to osmotic pressure this factor alone did not account for the major inhibiting effects of seed ball extracts or of solutions of urea or asparagin.

Free ammonia, in concentrations sufficient to account for the observed damage, was recovered from seed extracts and dilute solutions of urea and asparagin on which seeds had been placed to germinate. This ammonia was released by enzymatic hydrolysis of water soluble organic nitrogen compounds present in the extracts or solutions.

Increases up to four units in the pH of extracts were observed during germination tests (this is equivalent to a 10,000 fold decrease in hydrogen ion concentration). However, tests with dilute ammonia and slightly buffered Potassium Hydroxide solutions in which the pH of the liquid in contact with the seeds was maintained by a constant flow, indicated that free ammonia rather than hydroxyl ion was responsible for the injury. Inorganic ionized ammonium salt solutions which were slightly acid in reaction had little effect on germination other than that which could be attributed to osmotic pressure. This indicated that free ammonia rather than the ammonium ion caused the toxic effects observed.

RESISTANCE TO FUSARIUM YELLOWS IN SUGAR BEETS

H. W. Bockstahler,[1] Division of Sugar Plant Investigations,
(Demonstration Paper)
Bureau of Plant Industry, U. S. Department of Agriculture
(Cooperative, American Crystal Sugar Co.)

INTRODUCTION

In 1931, Stewart (1) reported the disease of sugar beets caused by Fusarium conglutinans var. betae. The symptoms on sugar beets were similar in many respects to those found in cabbage "yellows" and the casual organisms of the two diseases apparently were very closely related. The common name "ye-

1. The writer is indebted to Dr. G. H. Coons, Principal Pathologist, for advice during the course of this work and in the preparation of the manuscript.

lows" was suggested for this disease. In plant pathology literature, this common name has been applied not only to such vascular diseases but also to a group of virus diseases. To avoid confusion, Nelson, Coons and Cochran (2) have suggested the designation Fusarium yellows be used for the celery disease caused by Fusarium apii. It seems desirable to introduce similar usage for the sugar beet disease.

The first collections of Fusarium yellows of sugar beets were made at Rocky Ford, Colo. in 1926 and 1927. Since that time, the disease has been found in many western sugar-beet districts. Stewart found it in several fields in northern Colorado; in 1936 and 1937, G. H. Coons collected specimens in western Nebraska, Wyoming, South Dakota, and Montana. In correspondence in 1937, M. M. Afanasiev reported observing the disease in many fields in Montana, but in rather small amounts.

SYMPTOMS OF THE DISEASE

The symptoms shown in this disease are those characteristic of a vascular mycosis and the general effects are yellowing, leaf blade stunting, and distortion. About the earliest foliage symptoms for positive diagnosis are the yellowing or blanching of one or more of the half- to fully-grown leaves. Only a portion of the foliage bouquet may be involved. Those leaves commonly show paler areas between the main veins and the leaf blade has a mottled appearance. The leaves may also show slight inrolling at the margins. As the disease progresses, several whorls of leaves become involved, and the leaves may change from yellow to a red-brown color. Until the plant succumbs completely, the inner, partially-developed leaves remain erect like small furled flags. Affected plants stand out rather conspicuously not only because of their color but because of the upright habit. Older leaves die and dry up rather than wither. Complete wilting seldom occurs with older plants.

Stewart showed by greenhouse experiments that a high percentage of seedlings when exposed to the organism became in a 14-day period after emergence infected and died. Under field conditions at Rocky Ford, Colo., infected seedlings were found to die within a few days and the relatively high temperatures and low humidity caused them to dry and disappear rather quickly. The plants escaping infection in the seedling stage may become infected in later stages of growth. Infection of the roots apparently takes place through the tap root or some lateral.

Roots of plants in the early stages of the disease present almost no external indications of the disease; however, in the more advanced stages, the epidermis has a lifeless, grayish cast. When an affected root is cut transversely, it is found that the vascular bundles are gray or brown. In many cases, if the disease has not progressed too far, this discoloration may be limited to the sector of the root closest to the lateral root through which the pathogen made entry. Even after all the leaves of an affected plant have died, the root frequently remains firm until secondary organisms enter to complete the decomposition. F. conglutinans var. betae produces a slow, dry rot rather than a rapid, soft rot.

IMPORTANCE OF THE DISEASE

Because of its relationship to the group of Fusaria known to cause persistent soil infestation, the Fusarium attacking sugar beets has potentialities of becoming a serious disease which conceivably might render fields unfit for sugar-beet production. As yet, however, except for a comparatively few instances, the fungus apparently has not spread in fields at all comparable to the spread reported for the organisms causing cabbage yellows or Fursarium yellows of celery. In the long period of observation since 1926, the fields around Rocky Ford and those around Fort Collins, Colo., observed since 1932, in which affected plants were found continue to show diseased plants here and there, but no well-marked infested areas traceable to primary cases. A few fields, where sugar-beet crops have been rather frequently grown and where phosphate deficiency is becoming evident, show a comparatively high incidence of the disease. Thus, as high as 25 percent infection has been found in portions of fields near Rocky Ford and strong depression of the yields was clearly evident.

Some tests were made to determine the effects of the disease upon sucrose percentage and root weight. One hundred roots determined as affected with Fusarium yellows, and 100 roots determined as healthy were taken at random from piles of topped beets in a commercial field. The roots as picked up were grouped into 20-beet samples. The averages for the 5 samples of each class are given in Table 1.

These data show that Fusarium yellows may have effect upon yield, but significantly lowers quality of sugar beets, so much so in fact that a field with any high incidence would be seriously reduced in its acre-yield of sugar. Stewart (loc. cit.) has reported decisive weight reductions as well as significant depression of sucrose percentages. It is to be noted that the data given in Table 1 deal with roots of commercial size, large enough for field labor to top and pile and small, dwarfed beets as are produced by early attack were not included. Stewart has also called attention to the significance of the low sucrose percentages in relation to efficient fabrication of sugar.

As the incidence of the disease increases, the losses to the grower are not limited alone to smaller beets and lowered sucrose percentages. The effects that Fusarium yellows have on initial and early season stands also are important. Sugar beets can be infected by the organism from the seedling stage to maturity. One severely infested sugar-beet field was observed by the writer in October, 1937 in which the stand at that time was 50 percent of the initial, almost perfect, thinned stand as reported by the fieldman of the beet sugar company. Examination of plants from the field showed high prevalence of Fusarium yellows, and warranted considering this disease as the chief contributing factor to the stand loss.

Opportunity was afforded in a seriously infested field, turned over for experimental work by the American Crustal Sugar Company, to obtain information over a number of years as to the seasonal development of stand losses. This field was planted in 1933 to a commercial crop of sugar beets. Counts made on September 25 showed over 12 percent obviously diseased plants. Since many late infected plants fail to show definite foliage symptoms, it is probable that the incidence of the disease, which had developed under ordinary cultural practices involving frequent sugar-beet cropping, was at least twice as high. In 1934 and 1935, prior to planting sugar beets, barley grains which

Table 1.--Comparison of Fusarium yellows of sugar beets with non-affected control plants: sugar-beet roots of the two classes selected at random from topped sugar beets in a commercial field near Rocky Ford, Colo. (Results based on averages of five 20-beet samples.)

Class	Average root weight		Sucrose percentage		Apparent purity coefficient		Calculated indicated- available sugar per root	
	Actual	Comparative	By analysis	Comparative	As calculated	Comparative	As calculated	Comparative
	pounds	percent		percent		percent	pounds	percent
Diseased	1.469 ± .122	87	11.96 ± .788	71	77.3 ± 2.67	89	.1382 ± .019	55.6
Healthy	1.691 ± .033	100	16.82 ± .438	100	87.1 ± 1.83	100	.2484 ± .011	100.0

had been steamed and then inoculated with pure cultures of Fusarium conglutinans were drilled into soil at approximately the locations at which the sugar-beet seed was later to be planted. From the results of subsequent studies in the field, it seems safe to assume that extreme exposures of sugar-beet plants were thus given, the exposure approaching maximum in 1937 and 1938. The data given in Table 2 are based upon the counts made in four seasons on a highly susceptible sugar-beet variety which was randomly distributed throughout the field as a check variety. The table shows in each season the drastic drop in stand of thinned plants during the first month and a progressive decimation of stand throughout the season.

It is doubtful if the records for apparently free plants at harvest indicate significant differences in disease incidence for 1936, 1937, and 1938 but apparently the exposure in 1935 was not comparable in all sections of the field with that of later years. No inoculum was applied in 1937 or 1938 so that the data also may be interpreted as indicating strong persistence of the pathogen generally throughout the field.

Table 2.--Loss of stand assignable principally to Fusarium yellows in a highly susceptible variety grown in infested soil in the experimental field at Rocky Ford, Colo. Results given are sums of stand counts in check plots scattered throughout the field

Year	Total plants after thinning	Plants alive after approximately										Plants apparently free from infection at harvest[1]	
		1 month		2 months		3 months		4 months		5 months			
	No.	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
1935	7,845	3,835	49	2,922	37	-	-	2,690	34	-	-	1,640[2]	20.9[2]
1936	2,892	1,018	35	-	-	425	15	-	-	376	13	93	3.2
1937	17,158	6,889	40	4,362	15	-	-	-	-	3,362	20	913	5.3
1938	10,711	3,473	32	-	-	1,458	14	-	-	1,171	11	556	5.1

1/ The harvest record was based on root examinations as well as on foliage symptoms.

2/ Certain sections of the field in which the disease was not severe contributed very largely to these figures. Probably the bulk of the field had high infestation.

SELECTIONS FOR FUSARIUM-YELLOWS RESISTANCE

As stated previously, the history of spread and serious economic losses which occurred with the closely related diseases of cabbage and celery indicated potentialities for loss from the persistent, soil-inhabiting Fusarium concerned with Fusarium-yellows of sugar beet. It seemed advisable, even in advance of evidence that the disease was likely to be serious, to undertake selections to determine if Fusarium-yellows resistant could be secured as a result of mass selection or other breeding methods. Any varieties with Fusarium-yellows resistance, if otherwise satisfactory, would at least have a place in badly infested fields.

The investigations were begun in 1934 in the experimental field just discussed. During 1934 and 1935 a large number of European varieties as well as inbred strains and synthetic varieties developed in leaf-spot-breeding investigations were tested. Records were kept as to stands in the various plots after thinning, and at intervals throughout the summer.

Probably the major result from the 1934 tests was the finding that an inbred variety developed in the leaf-spot-breeding investigations, 20299-0, was extremely susceptible and that, judging from the persistence of plants in the plots, certain other varieties, especially certain strains from the leaf-spot-breeding work, offered possibilities for selection. Judging from plots, no European brand tested stood out from other brands, although desirable individual plants occurred here and there among them. The tests in 1935 were along the same line as those of 1934, except that 20299-0 as check on infestation occurred scattered throughout the field and was used to judge severity of exposure in making selections.

When the plots were harvested in November, interest was centered on those plots having the best record for stand maintenance or, in the case of certain varieties known to be otherwise satisfactory, the presence of a few outstanding plants led to their inclusion. All roots from plots thus chosen, which did not show foliage symptoms, were dug and the roots examined by cutting the ends of the tap roots or large lateral roots. As was to be expected, some beets were found which showed no positive symptoms on the leaves but did show typical brown vascular bundles. Others had apparently sound tap roots, but showed presence of the organism in one or more lateral roots. Positively infected, as well as suspected plants were discarded, irrespective of size of root and freedom from foliage symptoms.

The apparently healthy roots as selected were stored in crates or in a root cellar where the temperature was held at about 33-35° F. and the humidity was held as high as possible by frequent waterings. After 6 weeks of storage, a few of the roots were planted in 8-inch pots in a cool greenhouse for seed production, branches being bagged to secure selfing. Such of the remaining roots as were entirely sound in the spring were planted at various isolated locations in a number of groupings, dependent on the pedigrees, the following spring for seed production.

Reselections for Fusarium-yellows resistance have been made in the primary selections made in 1934 and 1935. As yet, the progress to be reported is not of such character that any one selection can be singled out as showing such resistance as to warrant introduction. The results obtained with certain selections in 1938 are given as strong evidence that highly resistant varieties may be obtainable by selection.

In the 1938 experiments, two 8 X 8 Latin squares were set up, each testing 6 selections and the check variety, 20299-0 which occurred twice. It seemed advisable to use this plan with the check variety in order to test more adequately uniformity of the infestation of the field.

The source material for the various breeders' strains consists of a commercial variety, Flat Foliage, produced by the American Crystal Sugar Company, a synthetic variety from the leaf-spot-resistance investigations of the Division of Sugar Plant Investigations, U. S. 215, and certain stocks arising from hybrids between sugar beet and Beta maritima. Since the results so far have not shown definite relations to the sources used, these details are omitted.

The selections shown in Table 3 represent stocks arising from primary selections made in 1934 which were reselected in 1936 for seed production in 1937. No significant differences in percentages of plants surviving for any of the counts made in the plots throughout the season were found, and the final record for percentages of plants apparently free from infection likewise showed no significant differences. The differences between the selected lots and the checks were highly significant.

In Table 4, two reselections for an original selection for Fusarium-yellows resistance also are compared with three first selections and three non-selected lots. In performance, the varieties appear to fall into three groups, with highly significant differences between the groups. Varieties without selection for Fusarium-yellows resistance averaged slightly over 3 percent in plants apparently free from infection; those having a single selection, about 20 percent apparently free from infection; and those with three selections, about 33 per cent.

These results are interpreted as extremely encouraging for the obtaining by mass selection varieties highly resistant to Fusarium yellows. The relatively small spread in percentages of plants apparently free between the primary selections and the reselections may be brought about by the inclusion of less resistant escapes when reselections of roots were made, which led to lowering of the general averages. With more drastic exposures, such as were afforded in the 1939 tests, a check on this assumption will be provided.

Table 3.— Performance of strains of sugar beets selected for Fusarium-yellows resistance when grown on infested soil at Rocky Ford, Colo. Results from first 8 X 8 Latin Square in 1938. (Data given as 8-plot averages.)

Variety	Description	Total thinned plots May 31	Percentage of plants alive on 1/			Percentage of plants apparently free from infection at harvest 1/
			July 7	Sept. 9	Nov. -	
7-201-0	Second Selection	1,012	65.1	36.6	33.4	26.8
7-203-0	do.	1,037	60.5	41.0	36.1	29.0
7-204-00	do.	1,090	57.6	40.0	37.4	28.3
7-205-0	do.	1,040	57.3	32.8	26.9	20.8
7-207-0	do.	971	57.4	35.6	30.9	20.8
7-208-0	do.	1,020	65.3	43.0	37.4	25.0
20299-0	Check	972	19.5	7.8	4.9	1.5
20299-0	do.	963	21.0	7.4	6.9	0.6
Difference required for significance 99:1		- - -	19.6	18.0	16.8	13.3

1/ Weighted averages.

Table 4.--Performance of strains of sugar beets selected for Fusarium-yellows Resistance when grown on infested soil at Rocky Ford, Colo. Result from second 8 X 8 Latin Square in 1938. (Data given as 8-plot averages.)

Variety	Description	Total thinned plants May 31	Percentage of plants alive on 1/ July 7	Sept. 9	Nov.-	Percentage of plants apparently free from infection at harvest 1/
7-206-0	Second Selection	1,014	72.6	51.1	44.5	35.4
7-209-0	do.	1,116	62.4	45.4	39.1	30.4
7-210-0	First Selection	997	71.8	40.4	31.3	21.9
7-211-00	do.	961	63.9	34.3	28.5	20.0
7-214-0	do.	1,048	58.0	31.9	26.5	17.4
7-216-00	No selection	988	65.3	27.3	15.4	4.1
20299-0	Check	960	21.3	9.0	7.6	2.8
20299-0	do.	985	29.3	11.3	9.5	2.6
Difference required for significance 99:1		- - -	14.7	13.0	11.1	9.3

1/Weighted averages.

SUMMARY

Fusarium-yellows of sugar beet caused by Fusarium conglutinans var. betae has been found in Colorado, western Nebraska, South Dakota, Wyoming, and Montana.

Yellowing accompanied by mottling of the leaves in the early stages, which may change later to reddish-brown, is a characteristic foliage symptom. The distorted and curled leaves tend to remain erect until the plant is completely overcome. The root symptoms shown are gray to brown discolorations of the vascular bundles and a lifeless, grayish cast to the epidermis in the advanced stages. The pathogen produces a slow, dry rot rather than a rapid, soft rot.

The disease reduces the size and quality (sucrose percentage, and apparent purity coefficient) of sugar beets. Seedlings are especially susceptible to invasion by the pathogen, but the fungus attack continues with older plants throughout the growing season.

Definite progress in securing resistant varieties has been shown as a result of mass selections, the second selections being significantly improved over the primary selections.

References:

(1) Stewart, Dewey. Sugar-Beet Yellows Caused by Fusarium conglutinans var. betae. Phytopath. 21, No. 1, pp. 59-70. 1931.

(2) Nelson, Ray, Coons, G. H., and Cochran, L. C. The Fusarium Yellows Disease of Celery (Apium graveolens L. var. dulce D. C.). Michigan Tech. Bul. 155: 1-74. 1937.

Section C. Sugar Beet Diseases - Chairman: G. H. Coons

EFFECT OF MOSAIC UPON YIELD OF SEED BY SUGAR BEET ROOTS 1/

by
John O. Gaskill 2/

The mosaic disease of sugar beets has been considered by various investigators to be detrimental to the sugar-beet seed crop. Robbins (7), in 1921, discussing observations in Colorado and Nebraska, reported the occurrence of an occasional plant in sugar-beet fields which produced an unusually small quantity of seed, apparently as a result of severe reaction to mosaic. In Europe, Schaffnit (8) stated that seed beets attacked during the first year, frequently produced one third less seed than normal beets; and Muraviov (5) summarized experiments conducted by himself and I. S. Shevtshenko in which it was shown that the disease reduced the yield of sugar-beet seed by 12.9%. Jones (4), considered mosaic to be an important factor in limiting the yield of garden-beet seed in the state of Washington.

Several hundred acres of sugar-beet seed are produced annually in northern Colorado at the present time, largely by the ordinary steckling method. Mosaic is usually quite prevalent in these fields, and has been suspected of causing serious damage.

The work reported in this paper was undertaken in order to obtain more definite information regarding the effect of mosaic upon the sugar-beet seed crop under northern Colorado conditions.

EXPERIMENTS IN 1938 AND 1939

Fall selection of mosaic plants and of comparable, apparently healthy plants for determination of the respective seed yields was employed in order to be certain of the presence of virus in all roots of the mosaic class, and, following selection, to give both classes similar storage. Preliminary trials had indicated the danger of latent infection in plants which appeared free from mosaic, which were to serve as checks, and consequently commercial sugar-beet fields in which the degree of apparent mosaic infection was relatively low were chosen as a source of roots. As a further precaution, after selection of a group of mosaic-infected roots from a field, the comparable check plants were taken at a distance of at least several feet from any plants showing mosaic. As a rule, check roots were taken within a radius of not more than 50 feet from the place of selection of the corresponding diseased beets, but in several instances the two groups were taken from opposite ends of a field. Root selection was strictly random, in all cases, subject to the above restrictions. The varieties of sugar beets in the 10 fields used for the selections in the two years of experiments included two foreign brands and one American variety.

Sugar-beet mosaic has been described by numerous investigators, including Robbins (7), and Smith (9), and a detailed discussion of the symptoms of the disease need not be repeated. In the selection of plants for use in these

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1/ Contribution from the Division of Sugar Plant Investigations, Bureau of Plant Industry, U. S. Department of Agriculture. Read by G. H. Coons.
2/ Assistant Pathologist.

experiments, it was observed that mottling and the frequent tendency toward puckering in the leaves of mosaic-infected plants agreed with the description given by Robbins. The severe type of malformation, often culminating in death of the leaf tip, which was considered by Robbins to be a manifestation of advanced stages of the disease, was not observed to an appreciable extent in any of the fields in which selections were made, and did not appear to be associated with mosaic at any time during the course of the subsequent experiments.

The roots selected were trimmed in the usual manner for mother beets and stored over winter in crates in the Station root cellar at Fort Collins, Colo. under conditions of relatively low temperature and high humidity, as described by Gaskill and Brewbaker (2). In the spring immediately following the year of selection, these roots were transplanted for seed production as described below.

TESTS IN 1938

Experiment 1

Five groups of mosaic-infected roots and the five corresponding groups of control roots were planted together as paired plots on May 13, 1938 at one location, the roots in each pairing having come from the same source field. Check plots were larger and contained correspondingly more beets, in order to allow for anticipated early occurrence of an occasional infected plant. Beets were spaced 3 X 3 feet, with check-row arrangement, and the entire experiment was surrounded by a row of roots of a commercial variety for buffer purposes. The crop was given ordinary care, with the addition of an occasional dusting or spraying for aphis control.

Each beet was examined for mosaic symptoms one month after planting. All plants in the plots planted with roots recorded as infected in the fall showed definite symptoms on that date. A few check plants also showed distinct evidences of the disease, and it was assumed that this was due largely, if not entirely, to fall infection which was too late to produce recognizable symptoms before the roots were selected. All such plants were disregarded entirely at harvest, but were left in place until that time. As was to be expected, a few beets died during the season because of root rot but these losses did not appear to be associated with mosaic. The resulting gaps in stand were ignored, and all plants which died before maturing any seed were disregarded entirely in the summarization of yield data.

All seed was harvested on August 16, at what was considered the normal degree of maturity, no appreciable difference in maturity being evident between mosaic-diseased and check plots. After being dried the seed was threshed and cleaned in a manner approximately comparable with that employed commercially, except that a 6/64-inch round-hole type of screen was used for elimination of small seed instead of the customary slotted type. Average germination percentage was determined for the seed from each plot, in accordance with accepted practice, with germinator temperatures alternately 20° C. for 18 hours, 30° C. for 6 hours. Final counts were made on the eleventh day.

The summarized yield and germination data, presented in Table 1, show a significantly lower production of seed per plant for the plots in which mosaic-infected roots were planted, but indicate an apparently negligible difference in germination percentage. In connection with the yield figures, it should be pointed out that mosaic had spread in the check plots to a considerable extent in mid-season, although actual counts were not made.

TABLE 1.—Effect of mosaic upon yield and viability of seed produced by sugar-beet roots, in a compact experiment, Fort Collins, Colorado, 1938 [a]

Replication	No. of plants per plot: Check	No. of plants per plot: Mosaic [d] infected	Aver. wt. of seed per plant [b]: Check (grams)	Aver. wt. of seed per plant [b]: Mosaic infected (grams)	Aver. germination [c]: Check (%)	Aver. germination [c]: Mosaic infected (%)
1	30	15	138.3	93.4	90.0	91.3
2	30	13	122.0	78.9	85.5	86.8
3	27	16	122.5	129.7	89.5	88.0
4	23	15	125.6	93.0	87.0	78.5
5	14	8	156.0	115.7	92.8	92.3
Average	24.8	13.4	132.88	102.14	88.96	87.38
Difference: Actual			30.74		1.58	
Percent (based on check)			23.13%		1.78%	
t			3.161		0.872	
Odds [e]			>19:1		<1.5:1	

a/ Plants spaced 3' x 3' throughout; no additional space between plots.
b/ Seed retained on 6/64-inch round-hole type screen.
c/ Each germination value based on 400 seed balls; final count on 11th day.
d/ Plants naturally infected during first year of growth.
e/ Odds against the occurrence of the indicated difference, due to chance.

Experiment 2

In preliminary experiments, attempts to prevent serious spread of mosaic from infected plots to adjacent check plots by means of dusting or spraying had been unsuccessful. In order to obtain data regarding the current problem, under conditions less conducive to spread of mosaic among the check plants than in Experiment 1, a parallel experiment was conducted in 1938 in a corn field, with a minimum distance of approximately 150 feet between plots. Five pairs of plots similar to those just described were planted, with a minimum spacing of approximately four feet between beets. Corn was not permitted to grow within any plot. One replication was lost as a result of an alkali spot in the field.

The crop was planted on May 13, soon after corn planting, and was handled in a manner similar to that of Experiment 1, except that the single check plant which showed mosaic symptoms on June 13 was removed at that time. All but one of the plants in the plots of mosaic-infected roots showed definite mosaic symptoms when examined on June 13. That plant was too small to permit an accurate conclusion at that time. It was noted in mid-season that the development of mosaic in check plots was relatively slight as compared with that in the experiment discussed above, though counts of infected plants were not made.

The crop was harvested on August 22, and the seed yield and germination percentages were determined in the manner described above. These data are shown in summary form in Table 2. It is of interest to note that, in this experiment, with less mosaic in the check plots, the indicated loss in seed yield, attributable to mosaic, was highly significant and amounted to 38.94% as compared with 23.13% in Experiment 1. The difference in average germination between checks and disease plots in Experiment 2, as in the other test, did not approach significance.

TABLE 2.--Effect of mosaic upon yield and viability of seed produced by sugar-beet roots, in space-isolated plots, Fort Collins, Colorado, 1938

Replication	No. of plants per plot		Aver. wt. of seed per plant a/		Aver. Germination b/	
	Check	Mosaic-infected c/	Check (grams)	Mosaic-infected (grams)	Check (%)	Mosaic-infected (%)
1	20	9	147.4	82.6	78.8	76.0
2	19	9	104.8	59.0	80.5	82.8
3	19	10	159.2	120.7	81.0	74.8
4	18	8	176.4	96.6	87.8	83.5
Average	19.0	9.0	146.95	89.73	82.03	79.28
Difference:						
Actual			57.22		2.75	
Percent (based on check)			38.94%		3.35%	
t			6.127		1.510	
Odds d/			>99:1		<4:1	

a/ Seed retained on 6/64-inch round-hole type screen.
b/ Each germination value based on 400 seed balls; final count on 11th day.
c/ Plants naturally infected during first year of growth.
d/ Odds against the occurrence of the indicated difference, due to chance.

1939 TEST

Experiment 3

In view of results obtained in the preceding year, a plan in which the plots with mosaic-infected plants were separated some distance from the check plots and screened by corn plants was used in 1939. Experiment 3 was set up which, in general, was similar to the second 1938 test, except that an additional series of plots was included for the purpose of obtaining more definite evidence regarding the effect of mosaic when infection occurs in the seed-bearing year. Three series of plots were set up in this experiment as follows: (1) the check series, planted with apparently healthy roots; (2) a mosaic-diseased series, planted with roots infected in the preceding season; and (3) a mosaic-diseased series, in which apparently healthy roots comparable with the first series were artificially inoculated with mosaic in the seed-bearing year. The inoculations of Series 3 were made one month after planting, using a mechanical-injury method which was a modification of the techniques described by Hoggan (3) and by Rawlins and Tompkins (6). The experiment was laid out in a corn field, and the roots were planted on May 11, immediately after the corn was drilled. There were six widely-separated replications, and in each replication Series 2 and 3, which involved mosaic-infected plants, were located as adjacent plots. More than 100 feet intervened between these plots and the corresponding check plot of a replication. The arrangement of plots within each replication was randomized, subject to the restriction indicated.

The crop was handled in a manner similar to that employed during the preceding year, though more detailed notes were taken. All plants in check plots were examined twice during the first month after planting, and five with mosaic symptoms were found and destroyed immediately. Examination of all other plants in the experiment on June 10 revealed one obviously infected individual in the six plots to be inoculated (Series 3) and four plants without mosaic symptoms in the six plots of mosaic-infected beets (Series 2). Three of the

latter four plants were extremely small at the time of the examination.

Seed yield and germination data were obtained in approximately the same manner as in 1938, except that the seed was passed over a slotted type screen with slots 7/64-inch wide—a method more nearly comparable with commercial practice. The results are presented in Table 3. As before, average germination percentages for the three contrasted series did not differ significantly. The average seed yield obtained from control roots was higher for each replication than that obtained from roots known to be infected with mosaic in the previous fall; the averages for the six replications showing a highly significant difference in favor of the controls. The average seed yield from Series 3 —plants inoculated in the seed-bearing year—was significantly below that of the check.

TABLE 3.—Effect of mosaic upon yield and viability of seed produced by sugar-beet roots, Fort Collins, Colorado, 1939[a/]

Replication	Treatment and number of plants per plot			Treatment and Average wt. of seed per plant [b/]			Treatment and average germination [c/]		
	(1) Check	(2) Mosaic[d/] -early	(3) Mosaic[e/] -late	(1) Check (grams)	(2) Mosaic -early (grams)	(3) Mosaic -late (grams)	(1) Check (%)	(2) Mosaic -early (%)	(3) Mosaic -late (%)
1	22	15	15[f/]	109.1	70.1	94.7	76.0	62.0	67.5
2	16	17	18	132.8	63.0	55.2	57.5	72.5	58.5
3	22	18	18	97.0	61.2	88.9	62.0	67.0	72.5
4	19	14	14	63.0	60.1	89.3	55.0	61.0	74.0
5	17	13	14	151.1	106.0	103.9	78.5	70.0	77.0
6	19	11	11	133.5	109.4	77.2	71.0	81.0	69.0
Average	19.2	14.7	15.0	114.42	78.30	84.87	66.67	68.92	69.75
z					0.8295 [g/]			0.6653 [h/]	
S.E. of mean of 6 replications					8.3963				
Difference for significance between means of 6 replications:									
Based on 5% point					26.46				
Based on 2% point					32.82				

a/ Within each replication treatments 2 and 3 occurred in adjacent plots, but otherwise all plots were space-isolated.
b/ Seed retained on 7/64-inch slotted screen.
c/ Each germination value based on 200 seed balls; final count on 10th day.
d/ Plants naturally infected during first year of growth.
e/ Plants artificially inoculated, June 12, 1939.
f/ Includes one plant showing mosaic symptoms at time of inoculation.
g/ z-value exceeds the 5% point.
h/ Negative z-value indicates absence of significant differences.

It was recognized that the symptoms of mosaic in mother beets, known to be infected, frequently become indistinct or may disappear entirely during the latter part of the seed-bearing year. However, it seemed desirable to follow, in so far as possible, the progress of mosaic in the inoculated plots in this experiment by means of individual plant records taken at appropriate intervals. Counts of positive mosaic cases were made in all other plots for comparative purposes. At the same time, the occurrence of bolting 3/ and blooming was recorded.

Although the percentages of the population which became infected in Series 3 cannot be stated, because of suspected masking of symptoms, it is known that at least 49.6% of these plants had the disease on July 12. It is of interest to note the low percentage of obviously infected plants in the checks, throughout the season, as compared with that in the other two series.

Bolting appeared to be retarded somewhat by mosaic, particularly in Series 3. The average percentage of bolting plants in that series was significantly below that for Series 1 (check) on July 2 and 12, and was also significantly below that for Series 2 on July 12 4/. It should be pointed out that the percentage of bolters in Series 3 did not increase at all during the 10-day period, beginning 20 days after inoculation, suggesting a rather strong reaction to the virus at that point. Average bolting percentages for the three contrasted conditions did not differ significantly on June 10 or August 3. Likewise, in percentage of plants which failed entirely to produce seed, as a result of delayed bolting or vegetative tendencies, none of the differences among the various experimental treatments were significant. Statistical analysis further indicated that there were no significant differences among the series in percentage of blooming plants.

DISCUSSION AND CONCLUSIONS

In no case in the 1938 and 1939 experiments, were root rot losses abnormally severe, and there appeared to be no association of rotting with mosaic. A statistical study of field counts for the two experimental treatments which occurred in each of the three experiments in the two seasons indicated that the difference between the rot losses for control roots and that for beets carrying first-year mosaic infection was not significant.

Gaps in stand resulting from early removal in Experiments 2 and 3 of the few mosaic-infected beets found in check plots, within one month after planting, were considered of negligible importance because of the wide spacing of the plants as used in these experiments, the minimum distance between beets being approximately four feet. Effects from these gaps were disregarded.

In planning the experiments reported here, it was necessarily assumed that, in commercial sugar-beet fields showing a moderate or low percentage of mosaic infection in the fall, plants with symptoms of the disease would not be appreciably inferior to the remainder of the population in seed-producing ability for any reason other than the effects of mosaic. It seemed improbable that plants with low seed-producing capacities, as a class, would be more palatable to the insect vectors. Some information regarding infected beets was

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3/ The term "bolting" as used here denotes the presence, on a given plant, of at least one seed stalk—approximately one-half inch or more in length.

4/ Variance analyses of all percentage data obtained from field counts were made in accordance with the procedure suggested by Clark and Leonard (1), using the transformation, $p = \mathrm{Sin}^{2}\theta$.

obtained in the fall of 1938. For the purpose of making comparisons in root weight and sucrose percentage between apparently uninfected plants and beets showing obvious symptoms of the disease, twenty-four pairs of samples, averaging 18 roots per sample, were taken by a random method, just before harvest, from commercial sugar-beet fields in which apparent mosiac infection averaged approximately 30%. The two classes of roots did not differ significantly in sucrose percentage, but in average weight per root the mosaic-infected class was 6.8% above the checks—a difference which was statistically significant. These results suggest a slight tendency in the vectors to feed upon the more vigorous plants. Any effects upon seed production which might arise from variation in root size are eliminated in the comparisons between Series 3, spring-inoculated plants, and the check series in Table 3.

The results from two years of experiments, in which the performance of check roots was compared, by means of space-isolated plots, with that of beets which were infected with mosaic in the year preceding seed bearing, are summarized in Table 4. The indicated reduction in yield of seed attributed to mosaic, amounting to 34.97%, was highly significant, being far above odds of 99:1. The difference in germination percentage did not approach the point of significance.

The evidence presented in this paper seems to justify the conclusion that, under the conditions of the experiments, mosaic was responsible for serious reduction in sugar-beet seed yield, first, when infection occurred during the vegetative year, and second, when it occurred in the seed-bearing year. Lowering of seed viability because of mosaic in the seed bearer was not shown.

TABLE 4.—Effect of mosaic upon yield and viability of seed produced by sugar-beet roots in space-isolated plots, Fort Collins, Colorado; summary of two years' data — 1938 and 1939 a/

	Aver. wt. of seed per plant		Aver. germination	
Year	Check (grams)	Mosaic-infected b/ (grams)	Check (%)	Mosaic-infected (%)
1938	146.95	89.73	82.03	79.28
1939	114.42	78.30	66.67	68.92
Weighted average	127.43	82.87	72.81	73.06
Difference:				
Actual		44.56		0.25
Percent (based on check)		34.97%		0.34%
t		6.240		0.088
Odds c/		>99:1		<11:1

a/ Summary, taken from tables 2 and 3.
b/ Plants were naturally infected during first year of growth.
c/ Odds against the occurrence of the indicated difference, due to chance.

SUMMARY

Sugar-beet roots showing mosaic in their first year of growth were brought to seed production the following year in replicated plots in comparison with plots of apparently healthy roots taken from the same commercial fields. The average seed yield per root from the mosaic-infected class was approximately 23% below the average yield for apparently healthy roots, a significant difference. The seed obtained from the two classes of roots did not differ significantly in viability. In this experiment, the plots planted with mosaic-infected roots were contiguous with the plots planted with apparently healthy roots. Spread of mosaic occurred, which may have caused lowering of yields from the plants which were apparently healthy when set out for seed production. In a second experiment, the mosaic-infected roots were planted in plots in a corn field with some distance intervening between those plots and the respective control plots. With this space-isolation of plots, the spread of mosaic into the controls was probably rather limited. The average seed yield per root from the mosaic-infected class was approximately 39% below the average yield obtained from the class composed of apparently healthy roots, this difference being highly significant.

In a test the following year, in which the control plots were at some distance from those with mosaic-infected plants, seed production, on the basis of yield per plant, from mosaic-infected roots, averaged approximately 32% less than the corresponding seed yield from the checks—a highly significant difference. In this experiment, apparently healthy roots were inoculated one month after planting in an additional series of plots. Yields from the inoculated plants averaged 26% less than from the controls, a difference which was well above the point of statistical significance.

No significant differences in viability between the seed lots obtained from the mosaic-infected roots (either early or late infections) and from the apparently healthy roots were found. Mosaic may have delayed bolting to some extent in the case of plants inoculated in the seed-bearing year; apparently the disease did not significantly influence percentage of plants blooming, or significantly increase the percentage of plants which failed entirely to produce seed as a result of delayed bolting or vegetative tendencies. So far as found in these tests, the most conspicuous effect of mosaic on sugar beets grown for seed production is the reduction of seed yields.

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RELATION OF 8-INCH AND 16-INCH SPACING TO CURLY-TOP INFECTION AND PERFORMANCES OF CERTAIN CURLY-TOP-RESISTANT SUGAR BEET VARIETIES
(Abstract)

By A. M. Murphy, Junior Pathologist, Division of Sugar Plant Investigations, Bureau of Plant Industry, United States Department of Agriculture.

Studies were made on the relation of 8-inch and 16-inch spacing to curly-top infection and performance of six economically acceptable curly-top resistant sugar beet varieties. The varieties varied in resistance to curly top from intermediate to highly resistant. Two dates of planting were made, the first on April 21 and the second on May 8. The varieties were planted in a 6x6 Latin square, each plot 80 feet long and four rows wide. One-half of each plot was thinned to 8 inches and the other half to 16 inches.

Under the conditions of the test it was found that by midseason there was approximately 50 percent more obvious curly top in the 16-inch spaced beets than in the 8-inch spaced beets. It was also found that the less resistant varieties gave better yield in the closer spacing.

VERTICILLIUM WILT OF SUGAR BEET
(Abstract)

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In the latter part of August 1939 an unusual wilt of the sugar beet (Beta vulgaris L.) was observed in fields in the vicinity of Ault, Colorado. The malady was characterized by a wilting and dying of the outer leaves which was soon followed by distortion and occasional loss of turgidity of the inner leaves. An examination of the interior of the tap root of any given plant showing such aerial symptoms generally revealed a discoloration of a few of the vascular bundles. The lateral roots usually showed a greater amount of this vascular necrosis than did the tap root. Rotting of the infected tap roots was seldon observed; the parenchymatous tissues being apparently un-

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a/ English translation by H. A. Kuyper, Division of Sugar Plant Investigations, Bureau of Plant Industry, U. S. Dept. of Agriculture.

affected. Isolations from the necrotic vascular tissues yielded a species of Verticillium, which when introduced into steamed soil in which stecklings had been transplanted, induced the symptoms characteristic of the disease. Isolations from these plants yielded cultures which were identical with those obtained from field specimens. The morphology of the casual organism resembles closely the descriptions of Verticillium alboatrum.

In order to obtain an indication of the prevalence of Verticillium wilt, 11 fields representing the Fort Collins, Loveland, Kersey, Lucerne and Ault areas were examined. A trace of the disease was found in six fields in the latter three districts, and approximately 1 per cent infection was evident in one field near Ault.

In paired comparisons of lots of diseased roots with comparable lots of apparently unaffected roots, the average sucrose percentages were 11.50 and 15.86, respectively, the difference being highly significant. In addition, the average gross-and indicated-available sucrose per root, and the average coefficient of apparent purity, were significantly lower in the case of the diseased plants. The average weight of the latter class of roots was less than that of the controls, but the difference was not significant.

(Complete paper will be submitted to Phytopathology)

BLACK ROOT OF SUGAR BEETS IN THE PUGET SOUND DISTRICT OF WASHINGTON[1]

By Leo Campbell

Black root of sugar beets has increased in importance in the Puget Sound district of Washington for the past twelve or thirteen years, or since a few years after the inception of the sugar beet industry there. During the last few years the seriousness of the disease has increased until it is one of the prime factors in limiting the sugar beet production in this district.

During investigations of the past three seasons, black root has been found in all the fields examined, ranging from a trace to 95 per cent, and losses due to the disease have varied accordingly, or from a little or no losses to losses so heavy that fields were abandoned.

Numerous fungi have been isolated from cultures of black root beets, but the only organism found to be pathogenic was a Phoma identical with that from seed of German origin and identified as Phoma betae.

From data collected during the growing seasons of the past three years, it is evident that black root can be controlled by the proper system of crop rotation. Where beets are grown for two or more years in succession, black root in serious proportions is inevitable, at least on the better beet soils. The object in crop rotation is to prevent the accumulation, or to rid the soil of the black-root organisms, and to maintain the fertility of the soil. To prevent the accumulation of the black-root organisms or to rid the soil of

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them, a cultivated crop immune to the disease should precede beets. Small grains seem to be rather effective in this respect also. To maintain the fertility of the soil, a sod crop, either meadow or pasture, containing some legumes should be used. It has been found that a sod crop will harbor the disease for several years, in some cases up to 12 years, and that a cultivated crop such as corn, beans or potatoes will generally reduce it to a safe minimum in one or two years. Consequently, the cultivated crop should intervene between the sod and beet crop. This order would also facilitate the preparation of the proper seed bed for planting beets.

There is some evidence to indicate that longer and smoother beets are produced when beets are grown for several successive years in the same soil, and because under certain conditions it is impractical to follow a system of crop rotation as described above, some alternative to crop rotation for the control of black root is desired by the growers. Consequently, seed treatment with various fungicides, which have given some degree of control of the disease in various other sections of the United States, and several soil treatments were tested in the Puget Sound district in cooperation with the Utah-Idaho Sugar Company and local growers.

In cooperation with the Utah-Idaho Sugar Company, Ceresan and New Improved Ceresan in a separate section and Ceresan and untreated checks in a split plot design with plantings for other purposes were compared as to their value in the control of black root in two separate plots of approximately one acre each. The averages of the data on unthinned and thinned stands, percentage black root and yields per acre are presented in Table 1.

Table 1. Field Data on Seed Treatment for Black Root of Sugar Beets. Season, 1938

Seed treatment	Unthinned[1] stand	Thinned[2] stand	Per cent[3] black root	Yield tons per acre[4]
Ceresan	93.2	99.3	6.6	19.6
New Improved Ceresan	92.7	99.3	5.6	21.0
Untreated checks	89.1	99.1	9.1	19.1

[1]The unthinned stand was derived by subtracting the number of blank inches from the representative 100 inches of an inside row of each four-row sub plot.
[2]The thinned stand represents the number of beets in 100 feet of an inside row of each sub plot.
[3]The per cent of black root represents the number of black root plants among ten plants from ten representative points of an inside row of each sub plot.
[4]The yield per acre was derived from the weight of beets from sixty feet of each of the two inside rows at harvest time.

The plants came up a little sooner and much more uniformly in rows for which treated seed was used, but it is evident that neither of the Ceresans were of little value in the control of black root.

In three hand-planted plots, totalling about one third acre, soil treatment with calcium cyanamide, formaldehyde dust and borax were compared with Ceresan seed treatment and untreated checks in the control of black root. The average per cent of black root for each of the treatments for the three plots is given in Table 2.

Table 2. Results of Field Tests on the Control of Black Root of Sugar Beets. Season, 1938

Treatment[1]	Cn	Fd	Ch	Bx	Ce
Per cent black root	78.3	67.0	77.9	70.8	78.1

[1]The symbols represent the following: Cn, calcium cyanamide, broadcast at the rate of 500 pounds per acre 16 to 19 days before planting; Fd, formaldehyde dust (6% with charcoal as a carrier) at the rate of 50 pounds per acre with the fertilizer in the drill at planting time; Ch, untreated checks; Bx, borax at the rate of five pounds per acre with the fertilizer in the drill at planting time; Ce, Ceresan dust at the rate of 3-4 ounces to 20 pounds of seed.

The results indicate that these treatments as used were of little or no value in the control of black root.

Tests on the value of seed treatment and soil conditioners and the merits of several varieties of beets of different sources were conducted by the Utah-Idaho Sugar Company in plots comprising nearly 2.5 acres. The soil conditioner section comprised six different tests of four row strips each in four replications, and in the seed treatment section Ceresan seed treatment was compared with untreated seed in a split plot design with six different variety tests in four replications of four rows each. Data on the tests are presented in Table 3.

Table 3. Data on Stands, Black Root and Yield of Sugar Beets, Utah-Idaho Sugar Company Plot. Season, 1939

Soil conditioners in pounds per acre, Ceresan seed treatment	At thinning time[1]			At harvest time[2]	
	Number plants examined	Number black root plants	Per cent black root	Number beets weighed	Weight of beets pounds
	Soil conditioners, section one[3]				
150 lbs. $MnSO_4$	564	21	3.7	421	816.5
75 " "	635	33	5.1	427	819.5
30 " borax	439	1	0.2	387	780.0
15 " "	518	6	1.1	417	897.5
1000 " mineral colloids	488	18	3.6	384	743.0
1100 " " "	673	4	0.1	384	733.0
	Seed treatment, sections two and three[4]				
Untreated	3975	188	4.7	2563	4825.5
Treated	5053	231	4.5	2599	4893.5

[1]Data taken on three feet of each inside row of each strip 50 feet from the ends of each section at thinning time, May 11-15.

[2]Number and weight of beets from 50 feet of each inside row of each strip at harvest time, October 17-24.

[3]$MnSO_4$ and borax drilled with the seed. "1000" Mineral Colloids added at the rate of 750 pounds per acre drilled and 250 pounds per acre broadcast before planting. "1100" Mineral Colloids added as "1000" Mineral Colloids with addition of 100 pounds per acre drilled with the seed.

[4]Treated and untreated seed in split plot design with six different varieties of beets comprising four strips of four rows each.

A degree of control of black root is indicated where borax was used at the rates of 15 and 30 pounds per acre and mineral colloids at the rate of 1100 pounds per acre, but with all three, and with mineral colloids at the rate of 1000 pounds per acre, extreme yellowing of the seedlings occurred. A high mortality of the seedlings followed the use of borax at the rate of 30 pounds per acre. Seedlings thus yellowed but not killed recovered rapidly after thinning, and within a few weeks the effect could scarcely be noticed. Data on yields indicate little or no damage from the use of these materials, in fact, the highest average yield in the plots were obtained where borax was used at the rate of 15 pounds per acre. The effect of Ceresan seed treatment is scarcely significant.

The foregoing investivations indicate that Ceresan seed treatments, by increasing the unthinned stand, afford protection to the germinating seed against invasion of organisms in the soil immediately around the seed. Theoretically then, such fungicides, if mixed through the soil from a little below the seed to the surface, should protect the seedling from black root in growing through the soil to emergence and, perhaps, for the full duration of the susceptible stage of the plant. Based on this conception, experiments were conducted in which several different fungicides with fertilizer were mixed separately through the surface one and one-half inch of the soil in strips approximately three inches wide, into which the seed was subsequently drilled.

New Improved Ceresan at the rate of five and ten pounds per acre added to the soil previously inoculated with Phoma betae in pots in the greenhouse gave 14.9 and 7.7 per cent black root, respectively, where 89.2 per cent of seedlings damped off in the checks. Formaldehyde dust and formaldehyde drip gave fair control of the disease.

Under field conditions, Ceresan at the rate of 0.2 grams, New Improved Ceresan at the rate of 0.1 and 0.2 grams, and formaldehyde dust (6 per cent with charcoal as a carrier) at the rate of one gram per foot row each with three grams of 3-10-7 fertilizer per foot row were added to the surface of the soil in strips about three inches wide and disked in to a depth of approximately one and one-half inch before the seed was drilled. Formaldehyde drip, 1-100 solution, at the rate of 12 cc (12 grams) per foot row was tested concurrently. Each treatment was represented by four 12-foot rows in three replications in two widely separated plots. Results of these experiments are presented in Table 4.

Table 4. Field Data on Control of Black Root of Sugar Beets. Season, 1939

Fungicide used	New Improved Ceresan		Ceresan	Formaldehyde dust	Formaldehyde drip	Untreated check
Grams per foot row[1]	0.1	0.2	0.2	1	12	---
			Monsen plot			
Number of plants	482	439	491	471	1469	567
Black root plants	279	321	200	269	604	407
			Polinder plot			
Number of plants	662	673	730	636	696	534
Black root plants	445	555	479	449	578	538
			Average of the two plots			
Per cent black root	63.2	78.7	57.0	64.8	54.5	60.4

[1]One gram per foot row is equivalent to approximately 50 pounds per acre.

There was considerable variation in the percentage of black root between the various treatments, but in no case was the incidence of the disease significantly reduced below that of the checks.

That the failure in control of black root in the above experiments might have been due to the way in which the fungicides were mixed into the soil, tests in which these and other materials were mixed with the soil by hand were conducted through the season. In these experiments the soil to a depth of approximately one and one-half inches in strips about three inches wide and six feet long was mixed in a bucket with the fertilizer and fungicide to be used. The mixture was then placed back into the trench left by the removal of the soil and the seed drilled therein. Where liquid manure was used, it was poured over the soil in strips about three inches wide at the rate of approximately 100 cc. per foot row and allowed to dry for one day before the seed was drilled.

Ceresan and New Improved Ceresan were used at the rates of 0.1 and 0.2 grams per foot row gave no control of black root and the latter either prevented germination or allowed but a very poor stand. Formaldehyde dust at the rate of one gram per foot row, and formaldehyde drip at the rate of 15 cc. per foot row gave 10.4 and 12.5 per cent black root, respectively, whereas the checks averaged 21.4 per cent. Liquid manure resulted in early emergence and very rapid growth of the seedlings but did not control black root.

Three plots in which borax, hydrated lime and six per cent commercial formaldehyde dust (Formacide) were tested as to their effect on the occurrence of black root, were planted at different dates later in the growing season. The dates on which the three plots were planted and the dates data were taken, were as follows: planted July 7, data taken August 9; planted August 29, data taken October 3; planted September 18, data taken October 16. Data on these three plots are summarized in Table 5.

Table 5. Data on the Control of Black Root of Sugar Beets, Season, 1939

Materials used in grams per foot row	Number of plants in six 3-foot rows	Black root plants in six 3-foot rows	Per cent black root
Borax 1/2	283	33	11.6
" 1	225	14	6.2
" 1 1/2 (1 plot)	104	6	5.7
Lime 5	453	86	18.9
" 10 (2 plots)	267	10	3.7
Borax-lime 1-5	272	12	4.1
Form. dust 2 1/2	352	87	21.8
Checks	309	112	36.2

These tests indicate a definite depression of the incidence of black root by the use of borax or lime. Whether this depression was due to the fungicidal action of these materials or to the effect on the seedlings, in the case of borax, or to the effect of the soil, in the case of lime, have not been considered in these investigations. In all cases where borax was used the plants were yellowed and stunted, but recovered to apparently normal soon after thinning. Lime, especially where used in the heavier applications, seemed to cause the soil to dry out rapidly and the seedlings to grow slowly until sometime after thinning. The most thrifty seedlings resulted from the use of formaldehyde dust.

Conclusion

Ceresan seed treatments apparently afforded protection during germination from organisms in the soil immediately around the planted seed, but there was no indication of protection for the full duration of the pre-emergent growth of the seedling nor after the plants emerged.

The only materials that showed much promise of controlling the post-emergent stage of black root, with perhaps the exception of formaldehyde dust or formaldehyde drip, were borax or lime or a mixture of these two, but the amount to be used and the method of applying these materials remain to be worked out. Until some such direct method for controlling black root is developed, a system of crop rotation as herein described, together with Ceresan seed treatment, as an insurance against better and more uniform stands, is recommended.

BORON DEFICIENCY OF SUGAR BEETS IN THE PUGET SOUND DISTRICT OF WASHINGTON[1]

By Leo Campbell

Effects of boron deficiency in sugar beets have long been known and have been reported from numerous beet-growing sections of the world. Various causes have been assigned for the disease but it was not until 1931 that its true nature was determined by Brandenburg. Publications of results of experiments with boron deficiency, both under field conditions and with nutrient solutions, since 1931 are voluminous and have left little or no doubt that the disease is due to the deficiency of available boron.

Symptoms of boron deficiency in the Puget Sound district are generally first noticed about two and a half months after planting or during the forepart of July or at the onset of dry weather. The first expression of the disease is a funnel-shaped top formed by progressive shortening of the leaves toward the center of the crown, and a general yellowing of the foliage . On examination of such plants, a black necrosis of the basal portion of the younger leaves may be seen. The necrosis extends up the petiole to the midrib and larger veins of the younger leaves as the disease develops and gradually involves the older leaves, on the petioles of which pimples or necrotic lesions in a ladder arrangement appear. In the final stage of the disease the young leaves and crown are reduced to a blackened mass, leaving only a few prostrate outer leaves intact. During the course of the disease the petioles, though rather flaccid, are brittle and easily broken off. In the later stages of the disease conspicuous, irregular but generally longitudinal lesions up to about one-half inch in depth appear on the beet near the surface of the soil, or from the crown and extending downward to as far as three or four inches in the more severe cases. Where the incidence of the disease is high the beet field appears yellowed from a distance. If the beets are amply supplied with water, either by rain or irrigation, new tufts of green leaves arise, even from crowns that were apparently destroyed, and the plants recover, in part at least.

Boron deficiency in the Puget Sound district is most prevalent during seasons of low rainfall, on higher lands and lighter soils of low water-holding capacity and where the land has been limed. In sugar beet fields under such conditions it is not uncommon to find as high as 50 per cent and occasionally over 90 per cent of the plants of certain fields showing the disease. Deficiency of available boron is by no means restricted to the higher lands but may be

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found in any of the better river bottom fields of this district where the soils are lighter or have been over limed.

A high percentage of the papers on boron deficiency have mentioned the effects of drought and over liming on the availability of boron to plants, but few contain recorded experimental data dealing with these subjects or attempted to explain the way in which these factors enhance the deficiency. Perhaps the most common explanations advanced are that more soluble borates are changed to less soluble calcium borate or that borates become less soluble by increased pH due to over liming.

Soil moisture deficiency is unquestionably a determining factor in boron deficiency of soils, since in the Puget Sound district and according to literature, boron deficiency effects on sugar beets are most serious during seasons of low rainfall and in fields where the water-holding capacity of the soil is low. Further evidence of moisture as a factor in boron deficiency of soils was shown when known high incidence fields were irrigated and the trouble prevented, and in others where affected plants recovered following the application of water, whereas portions of these fields not irrigated showed a high percentage of the disease. In one field where the boron deficiency disease was estimated at 98 per cent in 1937, complete recovery from the disease was effected the following year by irrigation in August after the incidence of the disease had closely approached that of the previous season.

There is no doubt that overliming enhances the deficiency of available boron of soils and thereby increases the incidence of the disease, since in fields or portions of fields that were limed, plants with affected crowns were much more prevalent and the effects were more severe than in neighboring fields of like soil or in portions of the same field not limed. On good river bottom land, up to 25 per cent the boron deficiency disease has been found in portions of fields where lime was used, while no more than a trace of the disease could be found on the unlimed portions. Experiments on the use of lime in the control of black root of beets indicate that boron deficiency of limed soils may be indirectly the result of soil moisture deficiency created by over liming, since the limed soils wet with difficulty, dried out very rapidly and the plants grown therein showed symptoms of insufficient water supply.

In the Puget Sound district, as in others, borax properly applied has been shown to be a specific for this disease of sugar beets. In a field where the disease was serious in this district in 1937, the yield and sugar content of beets were increased approximately 100 per cent and two per cent, respectively, by the application of 100 cc. of a 1-333 solution of borax per plant and all the plants promptly recovered from crown effects, as compared with untreated and checks to which 100 cc. of water was added. Plants to which dry borax was previously added failed to respond to the treatment until after a light rain over a month later.

In the spring of 1938 several tests were made in which borax was broadcast at rates of 10 to 30 pounds per acre before planting, but due to drought the plants failed to respond sufficiently to the treatment as to give significant results and the data, therefore, are not recorded here. In another plot where 10 to 40 pounds of borax was added as side dressings about a month after planting and just before a light rain, response to the treatments was definite. Results of this test are recorded in Table 1.

Table 1. Data on the Use of Borax in the Control of the Boron Deficiency Disease of Sugar Beets. Season, 1938.

Pounds of borax used per acre	0	10	20	30	40
Per cent diseases[1]	80.0	19.0	8.8	0.7	0.2
Yield, tons per acre[2]	8.7	10.2	11.2	11.5	12.3
Per cent of sugar in beets	9.2	13.8	13.2	13.4	13.4
Per cent increase yield due to borax		17.2	32.1	38.7	41.3
Per cent increase sugar due to borax		64.7	72.9	81.1	91.3

[1]Of 430 successive plants in a row.
[2]Untarred weights.

The data in Table 1 indicate the value of borax in the control of crown rot, and that this value increased as the amount of borax used increased from 10 to 40 pounds per acre, as determined by increased yields of beets and sugar.

Data taken from the Utah-Idaho Sugar Company plot, where borax was added in replication with manganese sulfate and Mineral Colloids, clearly indicate the value of borax in the control of the boron deficiency disease though this was not considered a seriously affected field. Because of the lack of untreated rows, the manganese sulfate and Mineral Colloids 1/ sections adjoining each borax section were used as checks. The data are presented in Table 2.

Table 2. Data on the Use of Borax in the Control of the Boron Deficiency Disease of Sugar Beets. Season, 1939.

Material used in pounds per acre[1]	Borax 15	Borax 30	Manganese sulfate 75	Mineral Colloids 1000
No. of diseased plants[2]	4	0	51	76
Per cent " "	1.0	0.0	12.0	19.0

[1]Borax and manganese sulfate were drilled with the seed. Mineral Colloids were added before planting, 750 pounds drilled and 250 pounds broadcast.
[2]Number of diseased plants in 400 examined (100 successive plants of an inside row of each four four-row replication of each treatment).

Some injury to the seedlings resulted from the use of borax, but the importance of borax in the prevention of manifestation of boron deficiency symptoms was significantly demonstrated.

Several instances could be cited in which borax broadcast up to 30 pounds per acre had but little effect on the incidence of the disease during the drought of 1938, whereas, on the same type of soil, specimens of the disease could scarcely be found during the season of 1939 of practically normal rainfall. On the other hand, in another field in 1937 where no borax had been used, the affected plants were estimated at over 90 per cent, but in the same field where borax was drilled with the seed at the rate of about 12 pounds per acre in 1939, no symptoms of the boron deficiency disease could be found though the plants suffered severe wilting due to the poor water-holding capacity of

1/ Trade name for a fertilizer which is supposed to contain, in addition to commonly used fertilizer elements, necessary rare elements.

the soil.

Discussion

Boron deficiency was found to be rather general through the sugar beet growing sections of the Puget Sound district, but most serious on higher lands and lighter soils of low water-holding capacity. Data indicate that soil moisture deficiency and overliming enhance crown rot and that the overliming in effect results in soil moisture deficiency.

The disease may be controlled by irrigation, at least in most fields of this district, and by the proper application of borax. The amount of borax to be used depends on the water-holding capacity of the soil, rainfall, extent of liming, previous applications of borax and the time of year it is applied. Under most conditions serious boron injury can be expected if borax is drilled with the seed at rates of over 10 pounds per acre, and this amount cannot be expected to prevent the disease on soils seriously deficient in boron. It is apparently safe to broadcast boron at rates of 50 or 60 pounds per acre before planting and to expect to prevent disease manifestations except during seasons of drought on land that has been over limed and that is by nature of poor water-holding capacity. Perhaps the most effective way to add borax is as a side dressing at the rate of from 20 to 40 pounds per acre, depending on requirements, a month or so after thinning, providing rain can be expected soon or there is sufficient moisture in the soil to dissolve the borax.

SOIL AND SEED TREATMENT EXPERIMENTS WITH SUGAR BEETS FOR CONTROL OF SEEDLING DISEASES[1]

M. M. Afanasiev
Montana Agricultural Experiment Station
Bozeman, Montana

The study of seedling diseases and phosphate deficiency in manured and non-manured rotations at the Huntley Field Station, Huntley, Montana after four years of study shows that the occurrence of these diseases is closely associated with the productive power and physical conditions of the soil, and with the other crops in the rotations. Weather and many other factors also have their effect on these diseases.

To determine the relationship between the occurrence of seedling diseases of sugar beets and the above mentioned factors, and also to develop measures for the control of these diseases, soil and seed treatment experiments were conducted during the past two years at the Huntley Field Station. The results of 1939 only are presented as they show the same trend as those secured in 1938.

For seed treatments, four ounces of ceresan and one ounce of new improved ceresan per twenty pounds of sugar beets were used.

For soil treatments nitrogen (N), phosphates (P), manure (M) and $Ca(OH)_2$ were used in the following combinations:

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[1]Contribution from Montana State College, Agricultural Experiment Station, Paper No. 134 Journal Series. Abstract of paper presented at the meeting of the American Society of Sugar Beet Technologists, Denver, Jan. 4-6, 1940.

1. NPM
2. $\frac{N}{2}$PM. In this treatment half of the nitrogen was applied at the time of planting and the other half as a side dressing immediately after thinning.
3. NP
4. $\frac{N}{2}$P Nitrogen was applied in the same way as in 2.
5. $\frac{N}{3}$P In this treatment one-third of the nitrogen was applied at the time of planting, one-third as a side dressing immediately after thinning, and the remaining third about a month later.
6. MP
7. N
8. P
9. M
10. $Ca(OH)_2$
11. NPM + $Ca(OH)_2$
12. NP + $Ca(OH)_2$
13. N + $Ca(OH)_2$
14. P + $Ca(OH)_2$
15. M + $Ca(OH)_2$
16. Check

All these soil treatments were used in three randomized replications, so that altogether there were 48 individual plots. Each plot consisted of three randomized rows of beets, 125 feet long. One row was planted with seeds treated with ceresan, another with seeds treated with new improved ceresan and the third with untreated seeds.

One hundred or more seedlings (in the four leaf stage) were collected from each row and examined in detail for disease. At the time of harvest each row of beets was dug separately, tops and roots were weighed and disease readings were taken.

The graph (Fig. 1) shows the amount of seedling diseases, yield and stand for each individual soil and seed treatment. The numbers represent the averages of three replications.

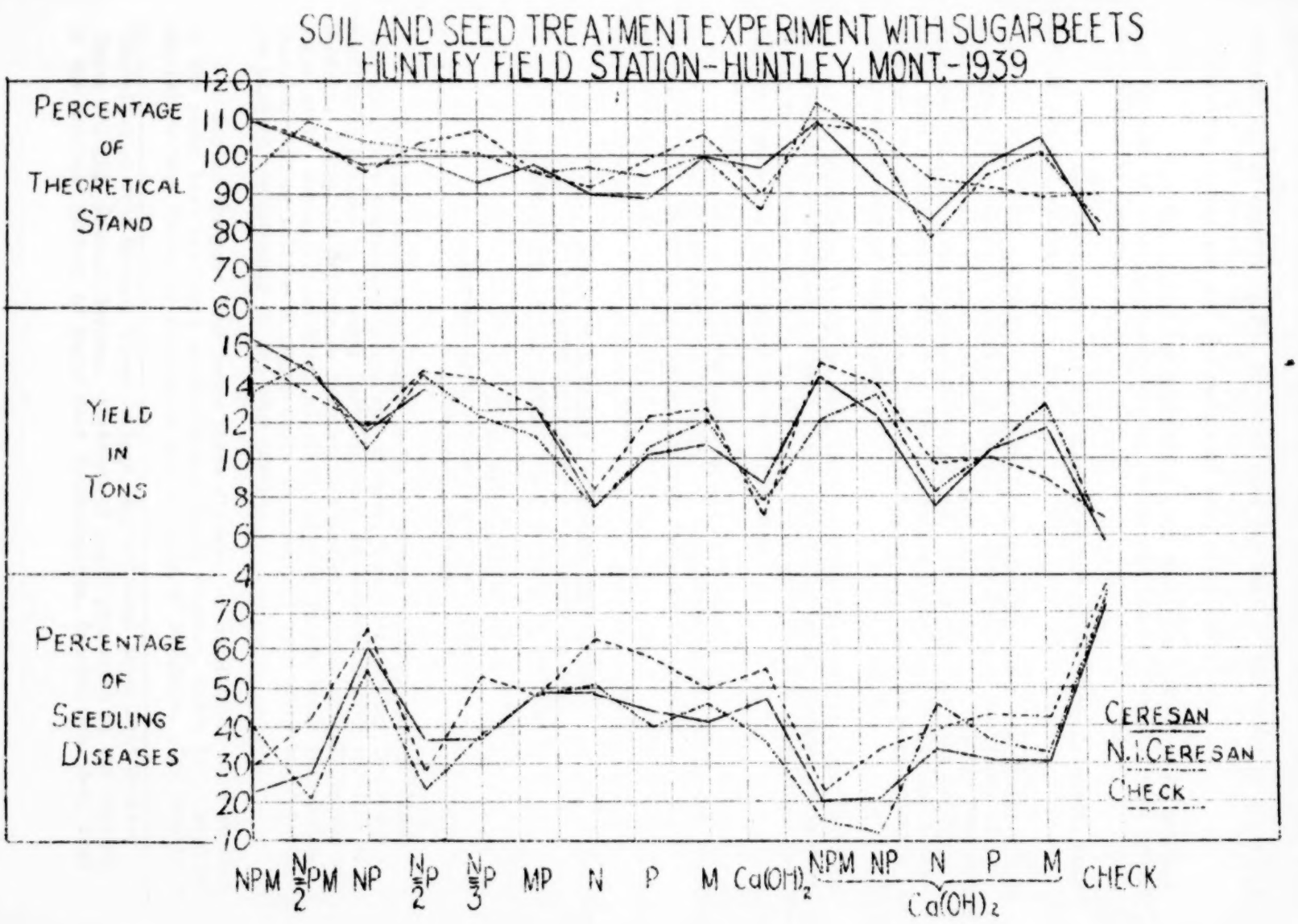
The results presented in this graph show:

I. Seed treatments alone were found to be only slightly beneficial in controlling seedling diseases of sugar beets.

II. Soil treatments, regardless of seed treatments were found to be of great importance in the control of seedling diseases of sugar beets.

1. Plots with the most complete soil treatments, namely NPM, $\frac{N}{2}$PM, $\frac{N}{2}$P, NPM + $Ca(OH)_2$ and NP + $Ca(OH)_2$ had the smallest amounts of seedling diseases, highest yields and stands.

2. Although plots treated with NP, $\frac{N}{3}$P, and MP had fairly good yields, they had considerable amounts of seedling diseases, yet it is difficult to explain why, when all nitrogen is applied at once (NP) or divided in three


SOIL AND SEED TREATMENT EXPERIMENT WITH SUGAR BEETS
HUNTLEY FIELD STATION - HUNTLEY, MONT. - 1939
PERCENTAGE OF THEORETICAL STAND
YIELD IN TONS
PERCENTAGE OF SEEDLING DISEASES
120
110
100
90
80
70
60
16
14
12
10
8
6
4
70
60
50
40
30
20
10
NPM
N/2 PM
NP
N/2 P
N/3 P
MP
N
P
M
Ca(OH)2
NPM
NP
N
P
M
Ca(OH)2
CHECK
CERESAN
N.I. CERESAN
CHECK

applications ($\frac{N}{3}$ P) sugar beets have much more seedling diseases than when it is divided in two amounts ($\frac{N}{2}$ P), in which case one half of the nitrogen is applied at the time of seeding and the remainder soon after thinning.

3. The plots with unbalanced soil treatments (N, P or M) all had high amounts of seedling diseases; the yields and stands were also poor except for plots with manure.

4. Check plots had the highest amount of seedling diseases, poorest yields and stands.

5. The application of $Ca(OH)_2$ undoubtedly had a beneficial effect in controlling seedling diseases of beets. A comparison of duplicate soil treatments with and without $Ca(OH)_2$ show that all plots with $Ca(OH)_2$ have much less seedling diseases than those without it. It is possible that $Ca(OH)_2$ could have a beneficial effect on the physical, chemical and biological conditions of the heavy clay-loam soil of this region and makes it more suitable for normal development of sugar beets.

In conclusion it may be said that seedling diseases of sugar beets can be efficiently controlled and good stands and high yields of sugar beets obtained by creating conditions in the soil which will promote a rapid and healthful development of young sugar beets through:—

1. Use of complete and balanced fertilization.
2. Improvement of the physical conditions of the soil, and
3. To a limited extent through the seed treatments.

SEEDLING DISEASES, PHOSPHATE DEFICIENCY AND FURARIUM YELLOWS OF SUGAR BEETS IN THE ROTATIONS AT THE HUNTLEY FIELD STATION IN MONTANA[1]

M. M. Afanasiev
Montana Agricultural Experiment Station
Bozeman, Montana

Seedling diseases of sugar beets which are commonly called "Black root" manifest themselves in the rot of young beet roots. They limit the profitable production of sugar beets in some sugar-beet-growing sections of Montana. Phosphate deficiency is also an important physiological disease of sugar beets, especially on heavy alkali soils poor in available phosphates. Fusarium wilt or yellows of sugar beets is important only where sugar beets are planted continuously on the same ground.

During the past four years these diseases of sugar beets were studied in the sugar beet rotations at the Huntley Field Station, which is located at the Yellowstone Valley of Montana in the vicinity of Billings. The results of

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[1]Contribution from Montana State College, Agricultural Experiment Station Paper No. 133 Journal Series. Abstract of paper presented at the meeting of the American Society of Sugar Beet Technologists, Denver, Jan. 4-6, 1940

these studies for 1939 are reported for twenty different rotations, the list of which is given in Table I. The following crops are grown in these rotations: alfalfa, sugar beets, potatoes, oats, wheat, beans and corn. These crops are grown continuously and in rotations of 2 to 6 years duration. The rotations provide various sequences with different soil treatments. These experiments were established in 1912 and 1916 to obtain information concerning the most desirable rotations for this part of the country and to determine the value of alfalfa and manure when used in rotations, where the soil is of a heavy clay-loam type. The average rainfall over the twenty year period was 14.27 inches and additional moisture is furnished to the crops by irrigation.

Readings of seedling diseases of sugar beets were usually taken when the seedlings were in the 4 to 6 leaf stage. Samples of one hundred or more taken from each plot were carefully examined for the presence of disease. Four times during each growing period counts of the stand of beets and notes on all beets showing symptoms of phosphate deficiency and fusarium wilt were made in every alternate row in all rotation plots.

TABLE I

List of Irrigated Rotations at the Huntley Field Station

I. Following rotations begun in 1912.
2. Sugar Beets (continuous cropping)
20. Potatoes, Sugar Beets.
21. Potatoes, Sugar Beets. (Manure)
22. Oats, Sugar Beets.
23. Oats, (Manure), Sugar Beets.
30. Potatoes, Oats, Sugar Beets.
31. Potatoes, Oats, (Manure), Sugar Beets.
32. Corn, Oats, Sugar Beets.
40. Potatoes, Sugar Beets, Alfalfa, Alfalfa.
42. Oats, Sugar Beets, Alfalfa, Alfalfa.
60. Potatoes, Oats, Sugar Beets, Alfalfa, Alfalfa, Alfalfa.
61. Potatoes, Oats, (Manure), Sugar Beets, Alfalfa, Alfalfa, Alfalfa.
63. Corn (hogged off), Oats, Sugar Beets, Alfalfa, Alfalfa, Alfalfa (hogged off).

II. Following rotations begun in 1916.
20. Sugar Beets (continuous cropping). Manure alternate years beginning in 1927.
34. Potatoes, Sugar Beets, Oats.
35. Potatoes, Sugar Beets, Oats, (Manure).
46. Sugar Beets, Oats, Alfalfa, Alfalfa.
64. Potatoes, Sugar Beets, Oats, Alfalfa, Alfalfa, Alfalfa.

In addition to these rotations there are:

2B Sugar Beets (Manure) (Continuous cropping). This rotation was started in 1928.

0 in Maximum Production Experiment.

This rotation has potatoes, beets, wheat, corn, oats, beans and several years of alfalfa. Phosphate applied to beets each year since 1930. Manure was applied to all cultivated crops and alfalfa.

The graph for 1939 (Fig. 1) is quite typical for the general disease situation in sugar beet rotations since 1936. A comparison can be made in this graph between the amounts of diseases, the yield and the stand of sugar beets in each particular rotation. Also the effect of the other crops in the rotations on the development of the diseases and how they effect the yield and stand of beets can be compared by studying the different rotations.

Seedling Diseases

All unmanured rotation plots, namely; 2, 20, 22, 34, 40, 42, 46, 60 and 64 had considerable more seedling diseases than manured plots 2B, 20 (which had considerable amount of seedling diseases in 1939) and plots 21, 23, 31, 35, 61, 63 and 0. The only exceptions to this were the two unmanured three-year rotations, 30 and 32 which had a small amount of seedling diseases. The soil of these plots which is somewhat lighter than the rest of the field possibly accounts for this fact. These results show that manure has quite a beneficial effect in reducing seedling diseases and increasing the yield of sugar beets. It is possible that manure by increasing the vigor of sugar beet seedlings makes them more resistant to disease and it may also have an indirect effect by supporting the development of saprophytic soil organisms which through competition can reduce the number of parasitic organisms in the soil.

All rotations with alfalfa and without manure had a very high amount of seedling diseases and phosphate deficiency, especially so when sugar beets were planted immediately after alfalfa (i. e. rotation 46). It is difficult to explain this situation, but still several factors could be mentioned.

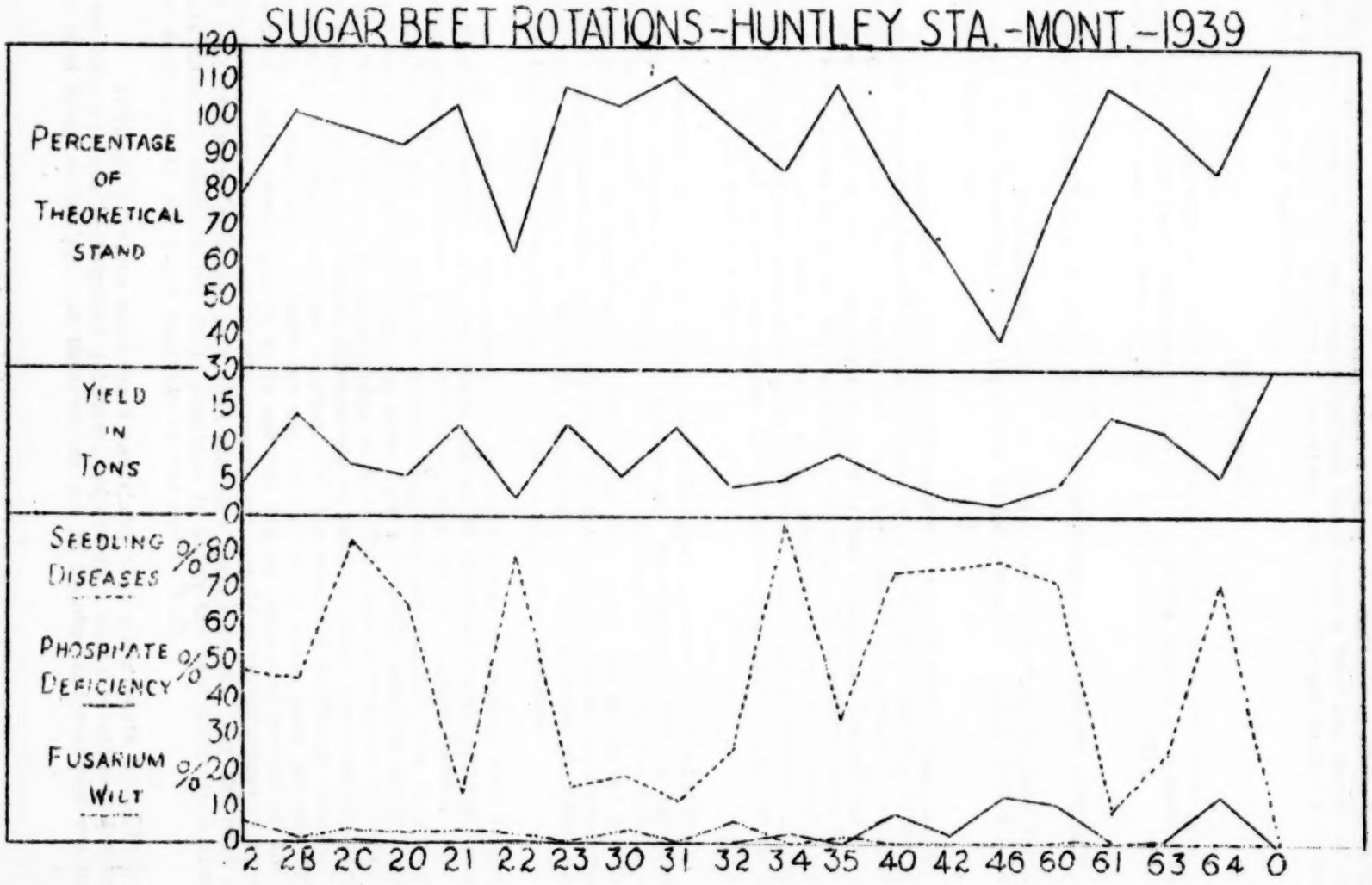
1. An old alfalfa ground, under the conditions of dry weather in fall and hard frost in winter, most of the alfalfa remnants overwinter in the soil without much decomposition, a situation which makes it very difficult to prepare a good seed bed.

2. The main decomposition of alfalfa remnants begins only with the moist warm spring weather which closely coincides with the germination and growth of sugar beet seedlings. Fungi are the first soil agents attacking plant materials, paving the road for bacteria and actinomyces. Because most of our seedling diseases of sugar beets are caused by fungi, the condition favorable for the optimal development of fungi will be also favorable for the development of diseases, at least from the standpoint of the abundance of inoculum. Alfalfa ground should preferably be plowed in mid-summer, then irrigated to favor decomposition of alfalfa remnants during the current season.

3. In the rotations with alfalfa the soils are deficient in available phosphates. Alfalfa is a very heavy feeder of phosphates, so after cropping for several years, the soil is depleted in available phosphates while at the same time, alfalfa leaves the soil enriched with nitrogen, which unbalances the ratio between nitrogen and phosphates as compared to non-leguminous crops. With unbalanced and deficient nutrient in the soil, sugar beets grow slowly, which condition is very favorable for the development of seedling diseases.

Phosphate Deficiency

All unmanured plots with alfalfa in the rotations and especially those where beets are planted immediately after alfalfa, show the greatest phosphate deficiency. This may be due, not so much to an actual phosphate deficiency in the soil, as in an unbalanced relationship between the very low amount of avail-


SUGAR BEET ROTATIONS - HUNTLEY STA. - MONT. - 1939
PERCENTAGE OF THEORETICAL STAND
120
110
100
90
80
70
60
50
40
30
YIELD IN TONS
15
10
5
0
SEEDLING DISEASES %
PHOSPHATE DEFICIENCY %
FUSARIUM WILT %
80
70
60
50
40
30
20
10
0
2 2B 2C 20 21 22 23 30 31 32 34 35 40 42 46 60 61 63 64 0

able phosphates and a surplus of nitrogen. As evidence of this beet rotations with alfalfa always show more symptoms of phosphate deficiency than those in continuous beets or in two year rotations which have a very low amount of phosphates and nitrogen in the soil. Rotations with alfalfa and manure show very little phosphate deficiency.

Fusarium Wilt

Fusarium wilt or yellows occur mostly in one, two, and three year rotations. Three year rotations on the lighter soils always have much wilt, while the four and six year rotations are practically free of wilt.

APHANOMYCES ROOT ROT OF SUGAR BEETS AS INFLUENCED BY PHOSPHATE APPLICATION.

By J. E. Kotila, Pathologist, and G. H. Coons, Principal Pathologist, Division of Sugar Plant Investigations, Bureau of Plant Industry, United States Department of Agriculture.

It is known that species of Aphanomyces, especially A. cochlioides Drechsler cause damping-off of sugar beets and, with older plants, death of lateral rootlets. These effects have been confirmed in experiments at Arlington, Va., as well as in field experiments in Ohio and Michigan. Isolations made from sugar beet plants in which the terminal portion of the tap roots were blackened and killed have shown that a species of Aphanomyces, tentatively assigned to A. cochlioides, is associated with this condition. The rotting usually extends up from the terminal of the root about one-quarter to one-half of its length but may involve the entire root.

General field observations had indicated a probable association of this disease with relatively wet soil conditions. Observations made in experimental plots in Michigan and Ohio, have shown that killing of lateral rootlets of the sugar beet, and the dwarfing of plants from this cause was prevented by application of fertilizers high in phosphate. In the plots in which such observations were made, tip rotting of the beet tap roots were absent where phosphate was applied, but common in untreated plots and in untreated borders.

An experiment was conducted with sugar beets grown from seed in quartz-sand cultures to test the protective effect of phosphate applications against Aphanomyces attack under conditions of optimum and high water levels. The exposure was secured by uniformly inoculating 3-gallon culture jars of autoclaved quartz-sand plus nutrient solution five days before the seed was planted with (a) a pure culture of A. cochlioides or with (b) plant debris and sand from a previous experiment in which Aphanomyces as well as other root rotting organisms occurred. The experiment was started with the numerous seedlings obtained from planting 50 seed balls in each jar and then after 46 days, each jar was thinned to five plants evenly spaced to be carried for an additional period of 132 days. The seedling at approximately the proper distance from its neighbors which appeared most likely to live was left when the jars were thinned. For the most part, this thinning approximated field practice in which the best plant in a clump at approximately the right position in the row is left.

Abundant previous experience had shown that sugar beets could be grown over long periods in nutrient solution, quartz-sand cultures without damping-off or root decay occurring. An observation set of quartz-sand cultures was used in

this test. The seedlings in the check cultures without organisms remained healthy. At the close of the experiment plants in the check cultures were free from root rot.

For each type of inoculum, half of the cultures was grown using a nutrient solution high in phosphate, and the other half was started with a nutrient solution without phosphate. After thinning, complete nutrient solution was occasionally used with the jars in which phosphate was to be held minimal, otherwise these jars received nutrient solution without phosphate. As a rule, throughout the experiment, 200 cc of the respective nutrient solutions were added twice a week to the appropriate culture jars. It was found that this amount was enough to bring about discharge or overflow from the jars. Tap water was added at other times as needed to prevent wilting.

For the contrasts in water level, half of the jars for each phosphate condition were equipped with siphons to prevent water standing in the jars, and the others had 5-inch stand pipes which kept the sand in the lower portions of the jars more or less water-logged.

The cultures were grown throughout the test on rotating tables to equalize light and temperature conditions. Each treatment was replicated 10 times and the results are given as 10-culture averages in Table 1 for the seeding phase. In Table 2 the results are given as sums of the 10 replicates for each treatment after 178 days.

The following conclusions were drawn from the experiment: Increase of mortality in seedlings and in larger plants was shown in the cultures with minimal phosphate nutrition as compared with those cultures grown under conditions of higher phosphate nutrition. The water level relations were over-shadowed by the nutritional effects, but some evidence is afforded that the mortality of seedlings is greater when water level is high and that Aphanomyces attack on the tap root may be increased.

The conditions set up in the experiment represent extremes, but are not entirely outside of those found in the field. Taken in connection with the field observations, they point to a definite relationship between severity of Aphanomyces attack and phosphate deficiency.

Table 1. —Numbers of apparently healthy sugar-beet seedlings remaining in quartz sand cultures after 7- and 46-day exposures to pure cultures of Aphanomyces cochlioides and organisms from debris of diseased plants: High phosphate is contrasted with minimal phosphate under conditions of optimum and high water levels.
(Results given as 10-culture averages.)

			Apparently healthy 1/ sugar beet seedlings after-	
Inoculum	Phosphate	Water Level	7 days	46 days
A. cochlioides (pure culture)	High	Optimum	79.0	32.1
do.	do.	High	68.8	17.2
do.	Minimal	Optimum	77.3	0.4
do.	do.	High	79.0	0.5
Debris from diseased plants	High	Optimum	87.8	73.6
do.	do.	High	91.8	62.0
do.	Minimal	Optimum	90.6	8.5
do.	do.	High	90.8	3.0

1/ As judged by absence of top symptoms or discolored hypocotyls.

Table 2.— Record of sugar beet plants following exposure to Aphanomyces cochlioides and to organisms from debris of diseased plants: Cultures shown in table 1 were thinned to five plants each after 46 days and continued on rotating tables for 132 days. Results are given as sums of the 10 cultures in each treatment.

Treatment			No. of plants after thinning	Results after 178 days			
				Condition of tap roots			
Inoculum	Phosphate	Water Level		Sound	*A. cochlioides* rot	Other types of rot	Dead
A. cochlioides (pure cultures)	High	Optimum	50	50	0	0	0
do.	do.	High	50	39	0	7	4
do.	Minimal	Optimum	50	25	9	0	16
do.	do.	High	50	28	13	0	9
Debris from diseased plants	High	Optimum	50	37	2	11	0
do.	do.	High	50	43	1	6	0
do.	Minimal	Optimum	50	35	6	0	9
do.	do.	High	50	21	7	0	22

1939 FIELD OBSERVATIONS OF BLACK ROOT OCCURRENCE

By M. W. Sergeant 1939-40
Great Lakes Sugar Co.

In spite of the tremendous amount of laboratory research on blackroot fungi, no other disease except leaf-spot (blight) causes such widespread loss of acreage and tonnage in the Eastern Sugar Beet Area.

Even if we know every fungus by its first name it is still up to the beet-grower to know and to apply such cultural practices as will discourage its development and allow the crop to grow in a reasonably normal manner.

For this reason we started a survey of infested fields in 1939 with the intention of carrying the study along for such a term of years as is necessary to give us two basic items of information for our area:

1. What general and cultural conditions are likely to produce blackroot?

2. What cultural practices give the most promise of saving infested fields?

The results of this season's work are interesting but, of course, inconclusive. We are pleased to find that these observations coincide with those of Dr. G. H. Siegumfeldt of Copenhagen, Denmark, and that they vary in only one or two points from those of Dr. Coons and Dr. Kotila of the United States Department of Agriculture.

Mr. G. H. Bernheisel of the Paulding Sugar Company made an excellent survey of conditions causing loss of acreage in 174 fields in their district (adjacent to two of our districts) this year. His observations coincide with ours almost perfectly as far as the two cover comparable data. He finds that blackroot occurs in almost equal amounts in beets following corn and in beets following legume hay crops. He finds also that it is practically useless to try to grow beets after beets or beets on wet, soggy ground.

1939 FIELD OBSERVATIONS OF BLACK ROOT OCCURRENCE

In Northwestern Ohio and Southern Michigan
In 143 Fields - on 138 Farms in 4 Districts[1]

Factors	Distribution Data by Fields
Soils:	Heavy 115, Light 15
Drainage:	Good 64, Fair 37, Poor 9, No tile 5
*Plowing:	Fall 64, Spring 62, Disced 12
**Planting:	Early 30, Medium 70, Late 32

[1]Data was incomplete in some cases which causes the discrepancies in totals.
*Fall plowing includes winter - up to March 15.
**Early - up to May 5, Medium - May 5 to 25, Late - after May 24. Late plantings are largely re-plantings this year.

Fertilizer:	Broadcast and with seed 30, With seed only 62
Manured:	1939 - 26, 1938 - 12
Preceding Crop:	Corn 59, Alf. Clo. 22, Wheat 15, Oats 10
	Cult.Crops 10, Beans 9, Beets 5, Soy Beans 4
Condition of C..C. 1938:	Clean cultivated 52, Weedy 8
Previous Beet Crops:	1 yr.5, 2 yrs.9, 3 yrs.9, 4 yrs.14 (Total 37)
Alfalfa - Clover Crops:	1938 - 22, 1937 - 40, 1936 - 39, 1935 - 32
Successive Alf.-Cl. Crops:	2 yrs. 12, 3 yrs. 14, 4 yrs. 4

The above factors in infested fields disclose no marked variation from normal beet-field conditions of this territory except for an above-average number of fields that have poor drainage or recent sugar beet history. The results from infested fields is shown in Table 1.

Table 1.--Record of infested fields saved and lost, 1939

	No. Saved	No. Lost	% Saved
First Planting	54	70	43.5
Re-planting	6	13	31.6
Total - 143 Fields Studied	60	83	42.0

Results of Field Treatment

Where the soil was promptly worked with the disc cultivator or with the rotary hoe, weeder or harrow, or a combination of implements that loosen and aerate the soil as soon as blackroot was observed, the crop was saved in a very high percentage of cases.

Where wet weather prevented such work for a week or more at the time the blackroot was observed or when the crop was neglected or left without working to "outgrow the disease", practically every field was lost.

Where the roller or cultipacker was used after blackroot was observed nearly every field was lost.

In numerous cases part of the field was lost and part was saved with conditions identical except that the saved portion:

1. Was higher or better drained
2. Had a better fertility background
3. Did not have beets in 1938
4. Did not have small grain in 1938

The following exceptions and remarks applicable to the 3 districts considered are called to attention. In three fields having both fall and spring plowing blackroot was worse on the fall plowing. In four cases reporting a previous very heavy corn crop, blackroot was unusually bad. One bad infestation occurred in a field that had been 10 years in grass, never in beets. One grower

who loses his beets every year by blackroot plowed 2 inches deeper this year and had no blackroot except where the plow was lifted at the ends of the field. One grower lost his beets 3 years straight on corn stubble fields. The soil is quite acid. In one fieldman's territory every case of blackroot but one was overcome. The one lost was the only one not promptly worked.

SUMMARY

The data given tends to support past studies as to the bad results from beets too close together in the rotation and as to the value of proper drainage and a high level of fertility.

This year's work indicates that the beet crop can usually be saved unless bad weather prevents the use of prompt, modern corrective measures. To date we have learned little more than how to direct our future investigations. We hope that continued observations will further illuminate and define the subject.

ROOT-ROT SURVEY 1938-39 GREAT WESTERN TERRITORY

By A. C. Maxson[1]

The 1938 and 39 surveys covered 1482 fields infected with some form of root-rot exclusive of seedling rots (black-root) and the rot associated with phosphate deficiency (black heart).

The diseases recorded were:

Disease	% of total cases
Rhizoctonia	75.37
Fusarium	21.25
Pythium	0.61
Unidentified	2.77

The root-rot caused by Rhizoctonia is the only one considered in this report. In this study alfalfa, potatoes, beans, cabbage, peas, and sugar beets were classed as hosts of Rhizoctonia. Small grains, sorghum and cane crops and corn are considered non-hosts.

Combining the years 1938 and 39, the relation of the cropping scheme to the damage (estimated) caused by Rhizoctonia was determined for host and non-host crops.

Where from one to four host crops preceded the sugar beet crop the damage was 4.84%. When the same number of non-host crops preceded the sugar beet crop the damage was 4.41%.

One or more successive beet crops preceding the one studied resulted in a loss of 5.04%. The same number of other host crops preceding caused an estimated damage of 4.18%.

1/ In charge Experiment Station, Great Western Sugar Company.

These figures indicate a positive relation between host crops in general and damage caused by Rhizoctonia root-rot. They also indicate a closer relation between sugar beets as preceding crops and the occurrence of Rhizoctonia than between this disease and other host crops.

A comparison of small grain and corn show the latter to be more effective in reducing Rhizoctonia than the former. One or more successive small grain crops were associated with a damage of 4.52%, while a like number of successive corn crops resulted in a loss of 4.07%.

The preceding loss figures are small and the differences are also small, however, we believe that they indicate real trends and suggest cultural means of reducing losses due to Rhizoctonia root-rot. This belief is based on the fact that similar relations are indicated year after year in these studies.

BORAX AS A CONTROL FOR HEART ROT OF SUGAR BEETS[1]

R. L. Cook[2]

Heart rot of sugar beets was first attributed to an insufficient supply of soil boron by Brandenburg (1) of Germany in 1931. For years prior to that date the disorder had been classed as a disease and many attempts had been made among European investigators to isolate the causative organism.

Since Brandenburg's experiments were reported, other workers both in Europe and in this country have verified his findings that heart rot is caused by a deficiency boron. Kotila and Coons (4) reported the presence of heart rot in Michigan beets in 1935. A study of symptoms of the disorder and the results of preliminary field surveys and experiments were reported by the author (2) in 1937. Since that date many Michigan farmers have learned to recognize heart rot, and some state that they have experienced losses from this cause for many years. It is the purpose of this paper to report further progress in the experiments performed to determine the effectiveness of borax as a control for heart rot of sugar beets.

Occurrence and Symptoms of Boron Deficiency

For the benefit of those not acquainted with the break down of sugar beet tissue caused by an insufficient supply of boron, it seems advisable to briefly review the subject from the standpoint of soil characteristics on which the disorder occurs and plant symptoms exhibited.

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[1]Contribution from the Soils Section, Michigan State College, East Lansing, Michigan. Authorized for publication by the Director as Journal Article No. 422 n.s. of the Michigan Agricultural Experiment Station.

[2]Research Assistant in Soils.

Acknowledgement is made to J. F. Davis and G. R. Muhr for assistance in the experimental work reported in this paper.

The results of surveys conducted during the last three years show that heart rot occurs more often on the rolling Miami loam, silt loam, and clay loam soils than on the level Brookston soils of similar texture. Furthermore, it has been found that occurrence on the rolling soils is usually confined to the higher places in the fields. On the level soils, where sugar beets are commonly grown in Michigan, signs of boron deficiency occur most often in areas of lighter texture and higher organic matter content, or in areas underlaid by sand and gravel fairly close to the surface.

These places of heart rot occurrence indicate that leaching has some influence on the supply of boron in the soil. Chemical tests, however, have failed to reveal low percentages of boron in the areas where sugar beets have suffered from lack of the element. This is an indication that leaching has the effect of quickly removing the available boron as it is released from the minerals by weathering and that it is not effective in rapidly reducing the total boron content of the soil. This seems to be a logical conclusion, because boron minerals weather slowly.

Chemical tests show that heart rot occurs more often on alkaline than on acid soils and that the positive correlation exists between heart rot occurrence and the active calcium content of the soil. The results of these experiments have been recently presented for publication. (3)

The first signs of heart rot appear in July or early August, in extreme cases, and later in areas where the supply of available boron is somewhat greater. Leaf symptoms are first noticed. The blackened and checked petioles are positive signs of heart rot. Shortened and twisted petioles and large numbers of small leaves are also reliable signs.

An insufficient supply of boron results in a break down of the tissue in certain portions of the plant. In the sugar beet the death of the growing center of the crown and the production of such beets has resulted in the name heart rot. Later in the season some beets send out a large number of leaves from around the edge of the crown. These leaves may die or they may continue to grow until harvest time when they practically cover the dead heart.

All sugar beets suffering from an insufficient supply of boron do not exhibit the same symptoms of deficiency. Some show leaf symptoms only while others suffer break down of the root tissue.

In occasional fields individual beets afflicted with heart rot are found well scattered among healthy beets but usually the disorder occurs in patches varying in size from a few square yards to an acre or more. In one case the soil is an alkaline sandy loam containing 14 per cent organic matter and underlaid by a layer of sand at a shallow depth. These conditions appear to be ideal for the development of heart rot.

EXPERIMENTAL

Pot Culture Experiments

In the study of boron deficiency symptoms the use of pot cultures has proved to be very valuable. By the use of a screened room, without glass and adjacent to the greenhouse, it is possible to grow plants in season under fairly constant conditions.

Plan of Pot Cultures—Sugar beets were grown in two gallon glazed earthenware jars, each filled with 8 kgm. of Thomas sandy loam. Treatments were replicated six times. Three sugar beet plants were transplanted into each pot soon after emergence from the quartz sand in which the seeds were germinated. The six control pots were then treated with a complete nutrient solution. The effect of copper, manganese, boron, and magnesium on the development of sugar beets on this particular soil was determined by omitting, in turn, each of the elements from the nutrient solution. The effect of doubling each of the first three elements was also studied. The treatments in this experiment are listed in Table 1. The moisture content of all the cultures was kept uniform by frequently bringing them up to weight by additions of distilled water.

Results—As shown by the data presented in Table 1, all the plants grown in cultures without boron were affected with heart rot while all cultures which received boron in the nutrient solution produced healthy plants. The elimination of the other elements from the nutrient solution had no effect on the development of heart rot.

As further indicated by the data presented in Table 1, boron applied as borax at the rate of 10 pounds per acre, increased the yield of roots from 46.7 gms. to 90.4 gms. per pot and the yield of tops from 109.0 gms. to 131.4 gms. per pot. The sucrose content of the roots was increased from 15.4% to 17.0%. As shown by the analysis of variance these differences are significant to the 1% point in the case of yields and to the 5% point in the case of sucrose content. No significant differences in yields or sucrose content were obtained by eliminating any other nutrient element or by applying double quantities of any element. In fact, there was a slight indication that 20 pounds of borax per acre actually reduced the yield of roots below the yield obtained as a result of the control treatment.

Field Experiments

Before recommendations may be made regarding the field use of such a material as borax, it is necessary to try out the material by means of field experiments. The experiments discussed in this paper were started in 1936 and have been continued since that date. During the first two years it happened that heart rot did not occur on any of the fields in which the experiments were located, but in 1938 and 1939 better luck was experienced in locating the experiments and the results of those tests are presented in the following pages:

Plan of Field Experiments—The field experiments were so planned that information would be obtained as to the quantities of borax necessary to control heart rot on different soils and as to the quantities which might be applied without injuring the beets. Quantities of borax ranging from 10 to 80 pounds per acre were applied broadcast and in contact with the seed. In 1939 the heaviest rate of application was made in a band beside the seed. In all of the experiments the beets were uniformly treated with 2-12-6 fertilizer. The borax was applied with the fertilizer. All plats were arranged in randomized blocks with treatments replicated from four to six times.

Effect of Borax on Stand and Yields—Experiments with several crops have shown great variability in the quantity of borax which may be applied without causing injury to germination or decreases in yields. Sugar beets are not easily injured. Stand counts made after the beets were blocked showed that during the three years 1937 to 1939, borax applied broadcast at rates up to 80 pounds per

acre had no effect on the stand of sugar beets. Stand counts on the broadcast experiments are not presented but the data presented in Table 2 shows that in 1938 yields were not reduced by the heaviest applications of borax. Experiments were performed on eight fields during the three years. The soils varied widely in pH and percentage of organic matter and in texture from sandy loam to silt loam. Further reference to Table 2 reveals a trend toward increased yields as a result of borax applications. The heaviest application on the Miami soil and the 20 to 80 pound applications on the Napanee soil apparently increased the yields by 1.0 to 1.1 tons per acre, and while, according to the analysis these increases were not significant, they come so near significance that it is believed significance would have resulted if the errors of the experiment could have been better controlled.

Where borax was applied in the row, significant differences in stand were obtained. As shown by the data presented in Table 3, as much as 40 pounds of borax was applied with the seed on Brookston soil in 1938 without injury to stand, but on Napanee and Miami the 40 pound application significantly reduced the stand. In no case was there an injury as a result of the 20 pound application. The weather conditions during the season of 1938 were favorable for the growth of sugar beets. There was plenty of moisture during the early part of the growing season, which probably accounts for the fact that injuries from high applications of borax were rather slight.

During the season of 1939, the rainfall varied considerably in different parts of the sugar beet area. The Miami soil was very dry for a considerable period after planting. This is reflected in the stand counts recorded in Table 4. All applications of borax caused significant reductions in stand on this soil. On the Napanee soil only the 80 pound contact treatment injured the stand. On the Thomas soil injury resulted from applications of 40 pounds per acre. On the Onaway and Posen soils, located in the Upper Peninsula of Michigan, significant injury occurred with the 20 pound application on the Onaway soil. These 1939 data illustrate very nicely the variability in results which may be obtained on different soils during the same season.

It is interesting to note the difference between the stand counts obtained from contact and side band applications. On two of the soils, 80 pounds of borax in a band 1½ inches to the side of, and 1 3/4 inches below the seed had no effect on stand while the same quantity of borax with the seed reduced the stand to about one-third that of the control. It seems that the advisability of side band placement of fertilizer will be greater when borax is included in the mixtures.

As shown by the data presented in Tables 5 and 6 borax applied in the row reduced the yields in cases where the applications were heavy. In general, the reductions in yields correspond to injuries in stand. There were exceptions to this in 1939 when the 10 and 20 pound applications on the Miami soil reduced the stand but did not significantly lower the yields. The same was true in the case of the 20 pound application on the Onaway soil. On the Thomas soil a significant drop in yield occurred as a result of the 20 pound application although the reduction in stand was not significant.

There were no significant increases in yield as a result of applying borax in the row. On some of the fields increases in yield did occur with the lighter applications. On the Onaway and Posen soils in 1939, heart rot was quite prevalent and in both cases, as shown by the data in Table 6, the areas

treated with 10 pounds of borax yielded more than did the control areas but the increases in yield were not large enough to be significant. Very good control of heart rot was obtained by the use of borax on these areas and it would seem that greater increases in yield should have resulted. Perhaps better results would have been obtained from a still smaller application. This is doubtful however since in only one case was the stand injured by the 10 pound rate. In a large number of fertilizer experiments with sugar beets, conducted at the Michigan Station during the past six years, it has been impossible to keep the errors of the experiments below a figure approximately equal to 10% of the total yields. Much of the error probably is due to soil differences, although great care has been exercised in selecting fields with uniform soil. Perhaps it is too much to suppose that, except in extreme cases, borax should increase the yields as much as 10%.

The fact that such increases may be obtained in extreme cases is illustrated by the results obtained from a sidedressing of borax, made on June 29 on Thomas sandy loam soil. An application of 9 pounds of borax per acre on this area where heart rot was particularly bad resulted in a very significant increase in yield. As shown by the data presented in Table 7, the yield of all beets was increased from 43.8 pounds to 62.8 pounds per plat while the yield of normal beets was increased from 10.0 to 23.8 pounds per plat. If the borax had been applied at planting time, the increases in yield would have been even greater. This seems certain because on soil taken from this same area and placed in pots in the greenhouse an application of 10 pounds of borax completely prevented heart rot. This experiment has already been described. The application made in the field on June 29 was too late to prevent the appearance of heart rot on many of the plants and it is believed that the help from the borax came mostly through the recovery of the already affected plants. Past work in the greenhouse has shown that beets affected with heart rot will completely recover if borax is applied before the breakdown of tissue is too far advanced.

Effect of Borax on Heart Rot Occurrence--As indicated by counts made of plants showing heart rot symptoms, borax has been very effective in controlling this disorder. As shown by the data presented in Tables 8, 9 and 10, all applications of borax, 10 to 80 pounds per acre, reduced the number of beets showing heart rot symptoms significantly below the number reported for the control. In only one case, that of a broadcast application on the Napanee soil, was there a significant difference between the counts obtained on the plats treated at the rate of 10 pounds per acre and on one receiving a heavier application. That would indicate that 20 pounds was enough to apply in any case whether the application was to be made broadcast or in the row. As already mentioned there is a possibility that fairly good control could be obtained with less than 10 pounds per acre applied in the row.

The Effect of Heart Rot on Sucrose Content and Purity--The profit from an application of any fertilizer to sugar beets may come through larger yields or through an increase in sugar percentage. As already reported, large increases in yield from a few pounds of borax can only be expected in extreme cases. It is believed, however, that the sugar content will be appreciably increased wherever borax is effective in preventing the occurrence of heart rot.

This belief is the result of the data reported in Table 11. For three years, attempts were made at the Michigan Station to find out whether or not an application of borax would affect the sugar content and purity of sugar beets. Samples were gathered at random from treated and untreated plats, without regard to heart rot symptoms. This was perhaps an inaccurate way of taking sam-

ples as it seems only logical that borax could only affect the sugar content of those beets which would, without the treatment, have developed heart rot. It is impossible to predict with certainty whether or not any particular beet will develop heart rot so another method of approach was adopted in 1939.

The beets from an area where damage from heart rot was severe were divided into three lots, those which did not have symptoms of heart rot, those which had symptoms only on the leaves and those which had root symptoms as well as leaf symptoms. Six samples of each of these lots were taken from two different soils. As shown by the data (Table 11) the beets with heart rot contained significantly less sugar than did the normal beets. Further, the beets with symptoms on both leaves and roots contained less sugar than did those with only leaf symptoms. This difference was significant in one soil. These results would indicate that the occurrence of symptoms on both leaves and roots is an indication of an advanced stage in the tissue breakdown.

A significant drop in the coefficient of purity was also found in beets grown on the Thomas soil. Normal beets showed a purity of 85.4% as compared to a purity of 76.4% in beets with both types of symptoms.

It has already been shown by the data reported in Table 1 that borax applied to pot cultures completely controlled heart rot and increased the sucrose content of the beets from 15.4% to 17.0%.

Discussion

It is believed that sufficient data have been reported to prove that an application of a few pounds of borax per acre may be expected to prevent the occurrence of heart rot in sugar beets either in the field or in the greenhouse. From greenhouse experiments in which it is believed that at least certain errors may be better controlled than in the field, and from field trials on areas where heart rot was severe, the conclusion may be drawn that in cases where heart rot is prevented by borax applications, yields will be increased as a result of the treatment.

Even in areas where heart rot is less severe, it seems logical that borax should increase sugar beet yields. In the experimental work presented in this paper the increases were statistically insignificant but it is believed that actual increases in yield would have been shown if it had been possible to control the experimental errors more closely. It is plainly evident that a beet which suffers tissue breakdown and a drop in sugar percentage as the result of a lack of boron, cannot possibly produce the sugar which it would have produced had it remained healthy.

At the sugar factories it is necessary to store sugar beets in large piles for varying lengths of time. Smith (5) has stated that only sound healthy beets should be placed in these piles. In many cases the tissue breakdown caused by boron deficiency is followed by rot resulting from the entrance of some organism. Such roots would be unfit for storage in large piles.

Summary and Conclusions

Sugar beets, grown in Thomas sandy loam pot cultures, were supplied with a complete nutrient solution as a control treatment. Copper, manganese, magnesium, and boron were separately omitted from, and doubled in quantity in, the control treatment solution to ascertain the effect of each of these elements on

the development of the sugar beet plant.

During the years 1937, 1938, and 1939 field experiments were conducted in 10 fields located on 6 different soil types. Borax, included in 2-12-6 fertilizer, was applied broadcast and in the row at rates ranging from 10 to 80 pounds per acre. In one experiment borax was applied as a sidedressing. The effect of heart rot on sucrose and purity percentages was determined by collecting samples from fields not included in the experiments.

The results from these experiments may be summarized as follows:

1. Borax, applied to Thomas sandy loam pot cultures at the rate of 10 pounds per acre, prevented heart rot, practically doubled yields, and significantly increased the sucrose content of sugar beets.

2. Copper, manganese, and magnesium did not prevent heart rot nor affect the yield and sucrose content of sugar beets.

3. Borax applied broadcast, in the field, at rates as high as 80 pounds per acre did not injure stands nor reduce yields.

4. Borax applied with the seed at the rate of 10 pounds per acre injured the stand on one field in 1939 but did not affect the stand on seven other fields in 1938 and 1939.

5. As much as 40 pounds of borax per acre applied in the row did not reduce the stand of beets on some soils.

6. Borax applied in a band to the side but not in contact with the seed was much less harmful to stand than was borax applied with the seed.

7. Borax applied broadcast or with the seed did not significantly increase sugar beet yields. It is believed that significance would have resulted in some cases had it been possible to better control experimental errors.

8. Borax applied as a side dressing on an area where heart rot was very severe significantly increased total sugar beet yields and more than doubled the yield of normal beets.

9. Borax applied in the row at the rate of 10 pounds per acre almost completely prevented heart rot occurrence. Broadcast applications at the same rate were somewhat less effective and on one field the 20 pound application produced significantly better results than did the 10 pound application.

10. Sugar beets having heart rot contained less sucrose than did normal beets.

11. On one field, the sugar beets having heart rot had a lower percentage purity than did normal beets.

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Table 1. The effect of borax on heart rot occurrence and the yield and sucrose content of sugar beets in Wauseon sandy loam pot cultures.

Treatment	Plants showing heart rot	Green weight per pot[1]		Sucrose content of roots[2]
		Roots	Tops	
	Per cent	grams	grams	Per cent
Complete nutrient (control)	0	90.4	131.4	17.0
Complete nutrients, less copper	0	101.9	145.0	16.0
Complete nutrients, double copper	0	97.7	139.8	16.4
Complete nutrients, less manganese	0	99.4	120.0	16.5
Complete nutrients, double manganese	0	102.3	135.6	16.3
Complete nutrients, less boron	100	46.7*	109.0*	15.4*
Complete nutrients, double boron	0	81.7	136.6	17.3
Complete nutrients, less magnesium	0	91.2	133.5	17.8
Difference required for significance		17.7	18.3	1.06
F		8.97	3.31	5.64
F (5% point)		2.29	2.29	3.80
F (1% point)		3.22	3.22	7.02

*Significantly less than control

[1]Yields are averages of six replicates

[2]For sucrose determinations it was necessary to combine the roots from three pots. The percentages then represent duplicate samples. One missing figure was supplied.

Table 2. The effect of borax applied broadcast on the yields of sugar beets in 1938.

Treatment in addition to 2-12-6 fertilizer.	Yields - Tons per acre. Averages of four replicates.	
	Miami silt loam	Napanee silt loam
No borax (control)	6.7	9.8
10 Pounds borax before planting	6.9	10.5
20 Pounds borax before planting	6.5	10.9
40 Pounds borax before planting	7.1	10.9
80 Pounds borax before planting	7.7	10.8
Difference required for significance	1.23	1.29
F	1.27	1.24
F (5% point)	3.26	3.26
F (1% point)	5.41	5.41

Table 3. The effects of borax applied in the row on the stand of sugar beets in 1938.

Treatment in addition to 2-12-6 fertilizer	Plants per 200 feet of row Averages of five replicates		
	Brookston silt loam	Napanee silt loam	Miami silt loam
No borax (control)	161.4	172.8	179.0
10 Pounds borax with seed	182.0	172.8	173.6
20 Pounds borax with seed	192.8	171.4	165.6
40 pounds borax with seed	171.0	151.8*	102.8*
80 Pounds borax with seed	131.0*	112.0*	40.4*
Difference required for significance	19.6	14.5	32.4
F	13.00	29.60	26.74
F (5% point)	3.01	3.01	3.01
F (1% point)	4.77	4.77	4.77

*Significantly less than control.

Table 4. The effect of borax applied in the row on the stand of sugar beets in 1939.

Treatment in addition to fertilizer[4]	Plants per 200 feet of row				
	Miami[1] silt loam	Napanee[2] silt loam	Onaway[3] loam	Posen[3] loam	Thomas[1] sandy loam
No borax (control)	209.0	164.8	250.4	216.4	160.4
10 Pounds borax with seed	176.8*	191.2	216.0	201.0	162.2
20 Pounds borax with seed	169.3*	186.9	204.4*	198.4	135.4
40 Pounds borax with seed	57.3*	160.8			110.0*
80 Pounds borax with seed	69.3*	64.8*			52.6*
80 pounds borax with side band	159.5*	163.4			155.4
Difference for required significance	29.5	20.1	32.88	19.68	25.9
F	37.7	45.7	6.34	2.94	22.84
F (5% point)	2.60	2.71	5.14	5.14	2.60
F (1% point)	3.86	4.10	10.92	10.92	3.86

[1]Averages of 6 replicates
[2]Five replicates.
[3]Four replicates.
*Significantly less than control.
[4]42-12-6 on Miami, Napanee, and Thomas, and 2-16-8 on Onaway and Posen soils.

Table 5. The effect of borax applied in the row on the yield of sugar beets in 1938.

Treatment in addition to 2-12-6 fertilizer.	Yield - Tons per acre. Averages of five replications.		
	Brookston silt loam	Napanee silt loam	Miami silt loam
No borax (control)	13.3	12.2	5.8
10 pounds borax with seed	13.9	12.0	5.4
20 pounds borax with seed	14.0	12.9	5.6
40 pounds borax with seed	13.1	10.9*	4.2
80 pounds borax with seed	8.9*	8.8*	3.0
Difference required for significance	1.23	1.21	1.00
F	26.40	16.05	12.83
F (5% point)	3.01	3.01	3.01
F (1% point)	4.77	4.77	4.77

*Significantly less than control

Table 6. The effect of borax applied in the row on the yield of sugar beets in 1939.

Treatment in addition to fertilizer[1]	Yield - Tons per Acre. Averages of six replicates.				
	Miami silt loam	Napanee silt loam	Onaway loam	Posen loam	Thomas sandy silt loam
No borax (control)	7.2	13.3	6.2	9.17	14.5
10 pounds borax with seed	6.9	12.6	6.7	9.67	12.6
20 pounds borax with seed	6.2	12.0	6.3	9.13	10.9*
40 pounds borax with seed	3.3*	12.0			11.6*
80 pounds borax with seed	3.21*	7.8*			6.7*
80 pounds borax in side band	5.5*	13.0			13.1
Difference required for significance	1.2	2.1	0.6	2.07	2.2
F	18.8	8.69	2.82	1.36	13.43
F (5% point)	2.60	2.71	5.14	19.33	2.60
F (1% point)	3.86	4.10	10.92	99.33	3.86

*Significantly less than control

1 2-12-6 on Miami, Napanee, and Thomas and 2-12-8 on Onaway and Posen soils.

Table 7. The effect of borax applied as a side dressing on the yield of sugar beets in 1939.

Treatment in addition to 2-12-6 fertilizer	Yield - Pounds per plat. Average of six replicates.	
	All beets	Normal beets
No borax (control)	43.8	10.0
9 pounds borax beside row	62.8*	23.8*
Difference required for significance	10.40	4.37
F	21.90	66.10
F (5% point)	6.61	6.61
F (1% point)	16.26	16.26

*Significantly greater than control.

Table 8. The effect of borax applied broadcast on the occurrence of heart rot in sugar beets in 1938.

Treatment in addition to 2-12-6 fertilizer.	Number of beets per 200 feet of row showing heart rot symptoms. Averages of four replicates.	
	Miami silt loam	Napanee silt loam
No borax (control)	12.3	80.8
10 Pounds borax before planting	1.0*	17.5*
20 pounds borax before planting	.3*	8.3**
40 pounds borax before planting	.3*	4.3*
80 pounds borax before planting	2.3*	2.3*
Difference required for significance	7.9	8.1
F	3.98	158.10
F (5% point)	3.26	3.26
F (1% point)	5.41	5.41

*Significantly less than control.

**Significantly less than control and 10 pounds borax.

Table 9. The effect of borax applied in the row on the occurrence of heart rot in sugar beets in 1938.

Treatment in addition to 2-12-6 fertilizer.	Number of beets per 200 feet of row showing heart rot symptoms. Averages of five replicates	
	Miami silt loam	Napanee silt loam
No borax (control)	18.8	40.6
10 pounds borax with seed	0.6*	7.6*
20 pounds borax with seed	1.0*	5.6*
40 pounds borax with seed	0 *	3.4*
80 pounds borax with seed	0 *	0.8*
Difference required for significance	4.6	6.6
F	28.62	56.30
F (5% point)	3.01	3.01
F (1% point)	4.77	4.77

*Significantly less than control.

Table 10. The effect of borax applied in the row on the occurrence of heart rot in sugar beets in 1939.

Treatment in addition to 2-16-8 fertilizer.	Number beets per 200 feet of row showing heart rot symptoms. Averages of four replicates.	
	Onaway loam	Posen loam
No borax (control)	94.5	65.5
10 pounds borax with seed	6.0*	10.0*
20 pounds borax with seed	0 *	3.0*
Difference required for significance	11.7	19.0
F	60.9	38.74
F (5% point)	5.14	5.14
F (1% point)	10.92	10.92

*Significantly less than control.

Table 11. The effect of heart rot on the sucrose content and purity of sugar beets in 1939.

Condition of beets	Percentage sucrose and purity. Averages of six samples			
	Thomas sandy loam		Wisner loam	
	Sucrose	Purity	Sucrose	Purity
Normal (control)	16.40	85.4	17.87	89.75
Leaf symptoms only	14.51*	82.5	16.28*	89.18
Leaf and root symptoms	11.38*	76.4*	16.08*	89.62
Difference required for significance	1.48	3.18	0.68	1.91
F	26.81	18.80	19.10	1.13
F (5% point)	3.68	3.68	3.68	19.42
F (1% point)	6.36	6.36	6.36	99.38

*Significantly less than control.
Some of the sugar determinations were made by F. R. Bach of the Michigan Sugar Company.

Section D. Sugar Beet Insects - Chairman: C. R. Jones

APHIDS AFFECTING SUGAR BEETS

By Miriam A. Palmer

Aphids are peculiar in both life cycle forms and in their structural characters. It therefore seems necessary to make a few preliminary explanations.

The life cycle is peculiar in that the method of reproduction, the form of the adult, and often the choice of hosts, varies with the seasons. The winter is typically passed in the egg. From the egg, in the spring, is hatched the stem mother or fundatrix which form is wingless and starts the colonies of summer forms. The stem mother is agamic or parthenogenetic, i. e., reproducing without fertilization of eggs by sperm cells from a male. Her method of reproduction is also viviparous which means bringing forth young alive instead of laying eggs. Her progeny are called summer viviparous females, either winged or wingless, and are also parthenogenetic like the stem mother. There are numerous generations of this form thruout the summer, as it takes only about ten days for development to maturity. In the fall appear the sexuales, or true females, typically wingless, and males, either winged or wingless. Reproduction is now sexual and oviparous. The females, after fertilization by the males, lay the eggs and soon afterwards both males and females die. The eggs lie dormant till spring when they hatch, producing the stem mothers.

The choice of hosts varies in different species. Some kinds of aphids will feed on only one species of plant and remain thereon thruout all seasons of the year. Other species have winter hosts, also called primary hosts, and summer or secondary hosts. The eggs are laid on the winter host and this is always some perennial plant, usually woody. The placing of the eggs on this plant necessitates the presence of also the sexuales and since the females and often also the males are wingless, fall migrants must fly to the winter host to give birth to the females and possibly also the males. The stem mother hatching from the eggs, does not acquire wings and therefore not only developes on the winter host, but deposits the first summer generation there. Her descendants either in the first generation or gradually thru two or three generations, eventually come to consist of all winged individuals which fly away to the summer or secondary hosts. The summer hosts are usually herbaceous plants and one kind of aphid may accept quite a variety of plants. If the summer host is able to live thru the winter in protected locations out doors, or in warm climates, or in greenhouses, summer forms may remain on this host and reproduce there thruout the year, either with or without producing fall migrants to fly to the winter host.

Aphids belong to the sucking insects. They feed not by biting off pieces of the plant and chowing them up like grasshoppers, but by piercing the surface of the plant and sucking up the sap. The mouth parts are of the nature of a beak which contains slender bristles which penetrate the tissues of the plant and form a tube thru which the sap is drawn into the alimentary canal.

The family of aphids is distinguished from other insects by wing venation and number and shape of antennal joints. The antennal joints are never more than six in number. Aphids generally possess also certain peculiar structures, namely cauda and cornicles. The cauda is a tail-like projection at the

tip of the abdomen. It varies in size and shape in different species. The cornicles are openings varying in shape from a mere pore to long tube-like structures, situated one on each side of the posterior part of the abdomen. These structures were formerly supposed to secrete the honey dew which is the sticky substance found on the leaves about and below aphid colonies, and is eagerly sought by ants. The honey dew, however, comes not from the cornicles but from the tip of the abdomen and is excreted from the alimentary canal. That this is what the ants are taking and that they are not milking the cornicles or feeding from them can be easily observed by watching with a hand lens the activities of ants in a colony of aphids.

There are three species of aphids which attack sugar beets, viz., the sugar beet root-louse (Pemphigus balsamiferae Williams or Pemphigus betae Doane); the black beet-seed louse (Aphis rumicis Linn.) and the green peach aphid (Myzus persicae Sulz).

The sugar-beet louse attacks the roots of the beet, using the beet as a summer host. The winter host is the narrow-leaved cottonwood (Populus augustifolia) also possibly the balsam poplar (Populus balsamifera). The eggs are laid on the bark and from these hatch the stem mothers in the spring. The feeding of the stem mother and her progeny on the upper side of the leaf next the midrib close to the petiole causes a depression to form in the leaf which developes into a pocket-like gall which projects on the underside and encloses the colony of aphids. The gall opens on the top surface of the leaf along the midrib, but the edges of the opening remain closely pressed together till the first of the progeny become mature. The outlet of the gall then opens, allowing the escape of the winged lice, the spring migrants, of which there are eventually a hundred or more from a single gall. These winged females are black on head and thorax and dusky green on the abdomen. They fly to beets and related plants, crawl into the ground, and there deposit living young on the roots of the plants. Many generations of wingless lice are produced thruout the rest of the summer. These aphids are pale yellow, two millimeters long and covered with white threadlike waxy secretion. About the end of August winged aphids again appear, similar in color to the spring migrants from the galls. These are the fall migrants. They leave the beets, flying back to the narrow-leaved cottonwoods, where they deposit their young on the bark. These young develop into the sexuales. The females are yellow in color and much smaller and more slender than the viviparous forms. The males are darker yellow and still smaller than the females, barely visible to the naked eye. After copulation with the males, the females lay each a single egg, nearly as large as their bodies and then crawl away to die. The eggs remain on the bark unhatched until spring when the leaf buds start to open.

Injury to the beets consists in yellowing, shrinking and stunting the plants in proportion to the number of aphids present.

Control mostly recommended is irrigation at the time the spring migrants are arriving from the cottonwoods. This time will vary according to latitude and lateness of season; in the vicinity of Denver it is usually from June 11 to 20. Wet soil discourages aphids while dry soil encourages them. Rotation of crops does little good since the hibernating aphids in the soil are usually of little importance in the next years infestation. Cutting out of narrow-leaved cottonwoods in the vicinity of beet fields should be quite helpful.

The green peach aphid appears on the leaves of the beet, especially on the undersides. The aphids are hardly two millimeters long and pale green in color; winged ones also with black patch on back of abdomen, as seen with a hand lens. The primary or winter hosts are the peach and plum trees and the eggs are laid on the bark of these trees. The little stem mothers hatch just before the buds open and may be nearly mature by the time the blossoms appear. At first they are dark green but when fullgrown the color is apple-green to deep pink, matching the color of the blossoms. Length of stem mothers is two millimeters. The lice feed on the leaves causing them to curl and twist very badly. The progeny of the stem mothers contain some winged forms which leave the peach for the summer hosts, which are various herbaceous plants besides beets. This migration from peach and plum begins about March 23 and ends about June 15 in the vicinity of Ft. Collins. These winged spring migrants start colonies on the beet leaves, each female producing six to eight living young a day. As only about ten days is required for development to maturity numerous generations can be produced thruout the summer. Fall migrants start to appear in September continuing even into November and fly back to the peach and plum to deposit there the young egg-laying females. The males develop on the beet, acquire wings and fly to the winter host to fertilize the females.

Control would be either (1) killing the stem mothers on peach or plum by spraying with lime-sulfur just before the buds open or by Black Leaf 40 just after buds open, but before leaf curling; or (2) killing the summer forms on the beet by spraying with Black Leaf 40.

The black beet-seed aphid appears as a black or green-black aphid massed in compact colonies on and under the leaves and in case of seed producing beets also on blossoms and seeds. The aphids are slightly over two millimeters in length and colonies usually contain quite a number of winged individuals.

The winter host is Euonymus or Strawberry Bush. Here the eggs are laid in the fall and the young stem mothers hatch in the spring about the time the buds open. The little newly hatched dark green or black lice are barely visible to the naked eye. They settle and feed on the opening leaves and when full-grown, about May 7, are over two millimeters in length, green-black in color and start producing the first summer generation. Winged forms, the spring migrants, develop and fly away to the summer hosts which include besides the sugar beet various truck crops and herbaceous flowering plants. On the leaves of the beet great colonies are formed, possibly causing the leaves to be puckered or curled more or less. In September or October fall migrants will appear and fly back to the winter host to deposit the little egg-laying females. These latter when full-grown, are smaller and more slender than the summer viviparous forms and of an olive-green or olive-brown color. The males develop on the summer host, acquire wings and fly to the winter host, arriving when the females are approaching maturity. They copulate with the females, fertilizing the eggs, and then die. The eggs are then laid on the twigs where they await the spring for hatching.

The viviparous generations, however, may continue thru the winter at the bases of protected plants which may live thru. From such places infestation may spread by means of winged individuals.

Control is the same as given above for the green peach aphid.

Biological control is accomplished by a number of insects of different kinds, both predaceous and parasitic. Lady beetles and their larvae are prob-

ably the most important enemies. Certain diptera, flies, are enemies of aphids, since their young, called larvae, or maggots, feed on aphids. One of these which is found only underground and is partial to the beet root-aphid, is Chloropisca glabra*. The larvae are pale yellowish, smooth and slender maggots, often found among the aphid colonies on the beet roots. The adult is a tiny black and yellow striped fly.

Found with aphids above ground are various kinds of syrphus fly larvae which can easily be observed to pick up aphids and suck out the juices, throwing away the empty skins. The adults feed on nectar in flowers and can often be seen hovering about flowers for which reason they are also called hover flies. The flies are often marked with black and yellow bands.

A certain kind of midge fly (Aphidoletes meridionalis Felt) lays its eggs in colonies of aphids. The young are tiny maggots, pinkish in color. They seem to lie idly about among the aphids, but if observed closely with a hand lens for a sufficient length of time, they can be found sucking juice from the membraneous connections between the joints of the legs. The aphids thus weakened soon die and their bodies turn brown.

Capsid bugs of different kinds feed on aphids in both larval and adult forms. They have sucking mouth parts or beaks with which they stab the aphids and feed on the body fluids.

Certain Hymenoptera, or tiny wasp-like insects, lay a single egg just under the surface of the body of the aphid. This egg developes into a grub which feeds on the juices of the aphid until full-fed. It then kills the host, pierces the underside of the aphid's body fastening it to the leaf and pupates inside the remaining shell which is all that is left of the aphid. This shell turns either whitish or black, varying with the kind of parasite. Later the adult parasite emerges thru a round hole which it has cut in the aphid shell. These dead parasitized aphids show up very clearly in an aphid colony.

When large numbers of any of these kinds of predators or parasites are found it is not necessary to apply methods of artificial control.

LIFE HISTORY AND CONTROL OF THE MAJOR LEAF EATING INSECT PESTS OF THE SUGAR BEET, EXCLUDING GRASSHOPPERS

By

Chas. R. Jones
Station Entomologist

The damage caused to any crop by leaf-eating insects is supposed to be paramount. This is undoubtedly because the feeding being exposed to view and to the casual observer and grower it attracts attention, hence is more generally known. There are several insect pests that attack the leaves of sugar beets and each will be treated separately and arranged in accordance to economic importance.

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* Parker, 1918 -- Jour. Econ. Ent., Vol. 11:p 368-380

The beet webworm is undoubtedly the most destructive pest of the leaf-eating group if not the greatest pest of the sugar beets. It undoubtedly ranks first and causes greater loss to the beet industry than any other pest.

Early History

The exact history of the pest is not accurately known. It was first recorded from Utah in 1869, in 1873 it appeared in Michigan and in 1903 was reported from Colorado in Larimer County. From that time it has gradually spread to all areas where beets are grown.

Records show that it has been taken from New Mexico up to an altitude of 11,000 feet. Thus it has a wide range and can sustain life in several zones. This pest has not only been recorded from all beet-growing sections in the U. S. but also our island possessions and many European countries.

Food Habits

While the main food plant is the sugar beet, the webworm is more or less of a general feeder and has been taken on all types of garden crops, weed, Russian thistle, alfalfa, fruit trees and what not.

The injury done by the worms feeding upon the young beet leaves often kill the beets outright; older beets also die when the crown has been destroyed. Where simple defoliation occurs growth is retarded and yield and sugar content is impaired. Every year more or less damage is done by this pest.

This insect has two and a partial third brood. It has been estimated by Mr. A. C. Maxson of the Great Western Sugar Co., that the first brood often defoliates and injures upwards of 31,000 acres of beets while the second brood defoliated more than 25,000, decreasing the tonnage by from 1/4 to one ton per acre, with a loss to the farmer of approximately $300,000 annually.

The period of damage by this insect is prolonged, extending from early June to September. The first generation causes the greatest damage as the beets are rather small and cannot withstand the injury. At the time the second generation appears the beets have grown to sufficient size to withstand the worm attack, although they are very often completely defoliated. The third generation seldom causes serious damage. This pest passes through 4 stages, egg, larva, pupa and adult.

The winter is spent in the larval stage, in early spring pupation takes place in a silken tube in the ground. The adult emerges as a moth in May, feeds and soon begins oviposition.

The egg stage varies from five to seven days.

Larval stage lasts from 17 to 20 days, during which time it is continually feeding. The pupal stage is about 11 days. These periods of time are average, depending upon climatic conditions.

Control

Control may be listed as natural and artificial. Under the former there are many natural enemies of these, birds play a very important part. The blackbird is its foremost enemy. Insects, both predaceous and parasitic,

are also important.

Under the latter may be placed cultural methods and poisons.

As the worm overwinters in the ground in the larval stage many of them are undoubtedly destroyed by dragging the beet fields. By this process the pest is exposed to winter conditions, birds and other enemies, and a partial control is affected. Deep plowing or harrowing after harvest will also prove quite effective. If this is not possible early spring soil preparation should be practiced.

Clean cultivation is also an important factor. As the worms are general feeders, all weeds especially Russian thistle and lambs quarter, should be kept down. Weeds should not be allowed to grow even around fence rows or on ditch banks as the moths will oviposite on them and when the worms have consumed these plants they will migrate to the beets where serious damage will follow.

Arsenical poisons are very effective in beet webworm control. Paris green has proven to be the most effective and satisfactory remedy as its action is quick and the beets are very resistant to its burning qualities. Arsenate of lead may be used in lieu of Paris green. Its action is slower and it must be applied in large amounts.

Dry pyrocide was also used in some experiments on a small scale and this material was very effective but rather expensive. A small hand duster was used and the material applied at the rate of 30# per acre. The results obtained were very satisfactory, in fact better than controlling the worm by Paris green, as the feeding of the larvae stopped as soon as the dust was applied. It is believed that if a power duster is used that the amount used per application could be cut in half at least. I understand that by the use of airplane the amount per application has been cut to 15# per acre. Dry pyrocide is very promising and more extensive experiments should be conducted.

Successful control depends largely upon applying the poison at the proper period, that is when the worms are but a few days old, it then requires less poison to kill them and they will not have an opportunity to do serious damage to the crop.

OTHER CATERPILLARS

While on the subject of leaf-eating caterpillars the alfalfa webworm should come next. This insect is a close relative to the sugar beet webworm, in fact it belongs to the same genus. The larvae of this pest are also general feeders. They will attack all types of garden crops, weeds, etc. Over 20 different weed species have been recorded as food plants. On cultivated plants, however, their attacks are generally confined to alfalfa on which the worms spin masses of whitish webs at the tips of the plants, enclosing the new tender leaves and blossoms which the worms eventually destroy. This web furnished ideal protection for the enclosed feeding worms.

The attacks of this pest on sugar beets is quite similar to that of the former insect. Occasionally leaves will be found practically covered with a web. These webs terminate in a long funnel-like process which extends to the ground.

This pest may be controlled by similar methods applied to the sugar beet webroom. With Paris green on small acreages the barrel type of sprayer may be used, but it is best to have a machine that will maintain sufficient pressure to apply the spray in a fine mist as coarse drops will collect on the waxy leaves of the beets and run off. The machine should also have an agitator to prevent the Paris green from settling to the bottom of the tank.

CUTWORMS

There are two cutworms that sometimes are important as sugar beet destroyers, the Army cutworm, Chosezagrotis auxiliaris Grote., and the pale western Porosagrotis orthogonis Morr. The latter is more prevalent and does greater damage when it occurs.

These worms like most all cutworms, develop in the fall and overwinter in the larval stage. About the latter part of April or first of May, when abundant, they are large enough to attact attention and may in heavy infestations cause considerable damage to young beets.

Other general leaf-feeding caterpillars at times attack sugar beets but these are of minor importance.

Control

If any of the leaf-eating caterpillars are known to be in beet fields in the early spring they may be controlled by use of Paris green. If their presence is not noted until the damage is done and the vegetation is destroyed, one will have to revert to the use of a poisoned bran mash similar to that used in grasshopper control; 100# should be sufficient to poison 12 acres of land.

THE BLISTER BEETLE EPICAUTA MACULATA

These beetles are formerly known as the "Old Fashioned Potato Beetle". This was to distinguish them from the "Colorado potato beetle". The common name is now obsolete.

Blister beetles belong to the order Coleoptera, are slender, elongated and cylindrical in shape, the head being broader than the thorax. This gives them the appearance of having a neck. The elytra are soft and not of the texture of other members of this order. There is an oily substance in their bodies known as Cantharidine which will blister the tender skin of persons if the beetles are crushed on it, hence the name Blister Beetle. A commercial produce "Cantharides" or "Spanish fly", which is used extensively in veterinary practice, is made by grinding the beetles into a very fine powder.

Blister beetles are gregarious in habit. They feed in droves and at various times the bands may be found in a certain part of a field; the next day returning to the same spot not a single beetle will be found. Thus they migrate from one part of the field to another or even to a different field altogether.

The larvae of this insect, as far as is known, feed upon the eggs of grasshoppers. Thus we have an insect that is noxious in one stage and beneficial in another.

There are about 200 species of blister beetles known to occur in America north of Mexico.

Life History

The life history of only a few of the American blister beetles has been worked out. The best one known is that of the striped blister beetle (Epicauta vittata Fabr.) and is briefly as follows. The insect winters as a full grown larva, in an earthen cell in the soil, and is known as a pseudopupa. It is about 2/5 of an inch in length, tough-skinned, yellowish in color, with much reduced legs and mouth parts. According to Crosby and Leonard it may remain in this condition several years, but usually molts the first season, acquiring functional legs and moves about for a while before it pupates. The true pupal stage lasts about 2 weeks and the adults emerge in June and July. The beetles are very restless creatures and tend, in a very short while, to mass together in great swarms, and migrate from place to place.

The female lays her eggs in clusters, about 1/2 inch below the surface, in rather compact soil. Riley has recorded as high as 1222 eggs laid in 16 masses from a single individual, which varied from 19 to 125 eggs per mass. The eggs are long, cylindrical, yellowish objects. The period of incubation is from 10 days to 3 weeks. Upon hatching the young are very active, and very strong-jawed and are known as a triungulia. They burrow through the soil until they reach an egg pod of some grasshopper, where they feed and develop. The larvae molt four times in 4 to 5 weeks, and pass through a remarkable series of changes known as hypermetamorphosis, during which time its legs and mouthparts become progressively smaller and smaller until it reaches the pseudopupa stage described above. In this stage it winters. There is apparently but one generation each season. The larvae of several species of blister beetles are known to feed upon grasshopper eggs and are thus beneficial in the immature stages. The food of the majority has not yet been determined. As the adults are general feeders they will feed upon all types of vegetation.

Plants known to be attacked by blister beetles are; potato, tomato, eggplant, beans, carrots, peas, pumpkin, onions, spinach, beets, radish, cabbage, corn, clematis, aster, zennia, and all types of weeds and sugar beets.

Control

As the beetles are very restless and rather resistant to arsenicals at ordinary strengths, early recommended controls were dusting or spraying with exceedingly strong applications of arsenicals, or sodium fluosilicate, or to dust heavily with slaked lime in order to disturb the beetles and cause them to move on. They have actually been driven from fields by waving brush over infested plants or by beating the plants with gunny sacks. The latter are only temporary methods and in a very short time the beetles disturbed in other quarters will reinfest previously infested areas.

As this pest follows outbreaks of grasshoppers it is only in late years that it has become an important pest, not having appeared extensively in Colorado for the past 20 years or more. When it did occur in '36, after the previous heavy grasshopper outbreak, considerable experimental work was necessary to find a product that would kill the insect by contact. This was necessary, due to its migratory habit. Several compounds were used, such as sodium fluosilicate, Garden Guard, Kalite, Rotenone, Cubor, sulfur, dry pryocide, etc.

The latter applied at the rate of 1 to 9 gave a kill of 93% of the beetles with one application, and is therefore to be recommended for this pest in any outbreak.

SUMMARY

1. Arsenicals do little good as they have to be applied in such concentrated form.

2. Commercial dusts such as Kalite cause the beetles to leave the plants in about 24 hours.

3. Cubor apparently has the same affect as Kalite.

4. Lime alone is effective in causing the beetles to migrate.

5. Pyrocide mixture actually kills the beetles in less than 24 hours and is therefore the most effective dust used, but it is rather expensive.

THE ALKALI BEETLE

In the beet-growing districts of Colorado the beetle is known as the alkali beetle because it breeds most freely on weedy low, damp ground, where alkali is brought to the surface by seepage.

It feeds upon the beet in both the larval and adult stages. Its damage generally is confined to places in the field near its breeding ground as mentioned above.

The adults are quite active and will often migrate in swarms to various parts of the field. In severe infestations they skeletonize the beet leaves, leaving only the larger veins. The plants thus attacked will soon shrivel and turn brown.

Control

When occasion warrants the beets may be sprayed with Paris green, 4# to 100 gallons of water, but as the outbreaks are generally spotted in the fields, a knapsack sprayer is best to apply the poison. It is recommended, however, to note the low alkali places near the beet fields and apply the poison to the weeds, thus killing the larvae and adults before they migrate to the beet fields proper.

FLEA-BEETLES

There are many flea-beetles that feed upon beet leaves and these may be controlled by an application of arsenate of lead or dry pyrocide.

HEMIPTEROUS INSECTS AFFECTING SUGAR BEETS GROWN FOR SEED
(Abstract)

By

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(Abstract of a paper for presentation to the American Society of Sugar Beet Technologists)

Results of surveys in fields of sugar beets grown for seed in the Southwest showed that several species of mirid bugs of the genus Lygus and several species of pentatomid bugs infest the fields. These surveys further indicated that the Lygus bugs come into the fields when seed stalks appear in the spring and that they reproduce rapidly, whereas the pentatomids come in somewhat later and reproduce much more slowly. These conclusions, however, are based on only 2 years' observations.

Results of isolation-cage studies showed that both Lygus and the pentatomids are capable of reducing the percentage of viable seed produced. The quantity of seed is apparently not reduced by these insects, but seed produced under conditions of insect infestation is somewhat lighter as well as of lesser viability.

In small cages an average of 52.1 seed balls were rendered non-viable by one female Lygus, whereas males did not significantly reduce the numbers of viable seed balls produced in the cages. In addition to increasing the numbers of nonviable seed balls, the females reduced the number of sprouts per viable ball from 1.99 in the check cages to 1.56 in the cages containing female Lygus. Here again the number of viable seed balls produced in the cages containing males was not significantly different from that produced in the check cages. These data would indicate that the males do very little, if any, damage to the seed. They also indicate that while the principal damage caused by the female Lygus is in the increased number of nonviable balls, still it is possible for the insects to damage one or more germs without damage to other germs within the same ball. The quantity of seed was not significantly reduced in either the cages containing males or those containing females which further substantiates the data from the isolation cages and indicates that species of Lygus do not materially reduce the quantity of seed produced.

Introduction of large numbers of Lygus on the beet plants before bolting altered the type of plant growth, drastically reduced the quantity of seed produced, and reduced the viability from 91.0 to 0.33 percent.

The beet leafhopper infests beets grown for seed in Arizona and New Mexico and causes injury by transmitting the curly top disease, which tends to decrease the yield.

Serious infestations by the beet leafhopper have been quite definitely correlated with late-summer conditions in desert breeding areas in adjacent territory. Such infestations result from large numbers of these leafhoppers produced in the desert areas on summer host plants, when winter mustards are absent late in October to serve as hosts of the leafhopper in the desert.

Two or more beet leafhoppers per foot of row of beets grown for seed in Arizona fields by November 1st would be potentially dangerous from the viewpoint of beet-seed production in the average field, while apparently one-half of this number might cause an equal degree of injury in New Mexico.

Much smaller numbers of the beet leafhopper occur in fields where the foliage practically covers the soil than occur at the same time in fields with small beets or poor stands; therefore, the hazard of curly top injury in Arizona and New Mexico can apparently be largely overcome by following agronomic practices which result in a growth of beet foliage that covers the ground by late in October.

Experiments conducted since 1935 for control of the beet leafhopper on beets grown for seed have shown that beneficial results were obtained by treating fields early in November with a pyrethrum-in-oil spray.

Section E. Sugar beet machinery - Chairman: H. B. Walker

DEVELOPMENT AND PERFORMANCE OF SINGLE SEED SUGAR BEET PLANTERS

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Two years ago at the Salt Lake meeting a preliminary report was given on single seed planting of sugar beets. Data were presented which showed the advantage of single seed planting in securing more uniform germination stands and stands which contained increased numbers of single seedlings. The desirability of such plantings for mechanized blocking and thinning as well as for hand thinning was pointed out. A single row planter unit which had been developed for single seed planting was described and data were given showing the effectiveness of its work. The construction of a multiple row planter using similar single seed units was reported.

Since that time there has been considerable experimental work done on this type of beet planting. Several different single seed planters have been developed. Two years' experimental results in the field have been obtained with part of these machines. Significant improvement in uniformity of germination stands and increased numbers of single seedlings has been obtained. It has been learned that new type planters with more or less elaborate mechanisms for dropping single seeds are not necessary, but that regular planters with proper special equipment will do satisfactory work. A laboratory method for testing planters has been developed which considerably speeds up comparisons of uniformity of seed distribution of the machines. The development has progressed to the stage where commercial equipment for single seed planting can be obtained for this year's planting season.

Several requirements or desirable features of a single seed planting machine were considered when the development was begun. The first was the selection or pick-up of single seed balls at regular intervals and, if possible, from sack-run or ungraded seed. Second, the uniformity of seed spacing should be maintained as nearly as possible until the seed balls were deposited in the bottom of the opened furrow. Third, the mechanism should be adapted to a disk type furrow opener because previous tests had shown this type of opener to be superior to the runner type in obtaining increased seedling germination. Furthermore, it was felt that a mechanism which could be used with the disk opener could probably also be used with the runner type while the reverse condition would not always be true. It was also desired that planting be done at normal speeds of at least two miles per hour. It has been learned since that all of these qualifications are not necessary.

The multiple row, chain feed planter, which was being built at the time of the meeting two years ago, was designed to fulfill the above requirements as nearly as possible. It uses an endless chain of seed cups which pick up single seeds in the cups as they pass upward through the hopper. The cups emerge from the surface of the seed, thus allowing extra seed balls to fall back into the hopper, and enter a tube which holds the balls between the cups. The chain passes over a sprocket and down through the tube to the bottom of the opened furrow where the seed balls are deposited equally spaced.

The planter with its feed chains of seed cups, the special chain housings with their four sprockets and rollers each, and the separate drives for each unit is a rather elaborate machine which would be expensive to build commercially, but which has been particularly satisfactory as an experimental machine because seed spacings could be obtained with it which were comparable with hand spacing. It was built as a four or a six-row machine so that it could be used with commercial plantings of either kind. It has been used for experimental field plantings the past two years.

Mervine's single seed planter uses a vertical disk with a series of cups around its periphery to pick up single seed balls. The disk of cups is attached to the inner face of one of the furrow opener disks which is positively driven. The cups pick up seeds from a small, secondary hopper in the disk opener casting, carry them around through a channel in the casting and drop them into the bottom of the opened furrow. Either graded or sack-run seed can be used. A four-row planter using these units was built and used for experimental planting in 1938. Two additional planters using these units were built for further experimental plantings this past year.

The John Deere Plow Company became interested in this type of planting and built several four-row units of an experimental single seed planter in time for field test in 1938, both in California and in the later-planting districts. This planter is of the horizontal plate type using special, single seed plates with special seed cut-offs and notched seed knocker wheels. The seed cells are notched into the edge of the plate and are sized to take smaller sized, graded seed. The seed hoppers are mounted directly on runner openers so that the distance of seed drop is decreased to seven inches.

The seed hoppers from this low-hoppered, experimental planter could be used on an old style, regular, runner opener planter which gave a 24-inch seed drop. As the plate could be run at the same speed relative to the forward travel of the planter, this gave a very satisfactory comparison of two heights of seed drop with exactly the same plate equipment.

Tests in 1938 showed no significant differences between germination stands obtained with the single seed plate hoppers when used on the two planters with the 7-inch and the 24-inch seed drop. It was therefore suggested to the manufacturer that the special, single seed plates with their seed cut-offs and knockers be made available for the current, commercial plate planters.

These special single seed plates for small sized, graded seed were supplied for this past season's test work. In addition plates were machined from blanks which would accommodate the larger sized, graded seed or could also be used with sack-run seed. These single seed plates with the necessary false plates, seed knockers, etc., will be available for this season's planting.

Another type of single seed planter was developed by C. J. Cobbley of the Utah-Idaho Sugar Company in 1938. Several four-row units have been built and tested both in 1938 and 1939. This planter utilizes a vertical seed wheel with a double row of seed cells around the edges of the rim. This seed wheel is mounted in the bottom of a seed hopper and on a runner type furrow opener to minimize the distance of seed drop. Seed balls are accumulated in the cells as the wheel turns through the bottom of the seed hopper. The seed are held in the cells by guides until they reach their lowest point when the cells are uncovered and the balls drop into the bottom of the opened furrow.

Small knocker rollers running in grooves on the inside of the rim dislodge the seed balls from the cells.

The Case Company has also developed single seed plates for its regular, tractor-mounted beet planter. This planter uses an inclined plate with pick-up cup seed plates. These plates will also be available for this year's planting season.

The Ventura Manufacturing and Implement Company and the Strong Hamilton Implement Works, both of Ventura, California, are also developing or have developed machines for single seed planting. Both are of the type using vertical seed wheels with pick-up seed cups. Tests have not been run with these units. Other manufacturers of beet planters are also giving attention to single seed planters.

Field germination stand counts have been used for comparing single seed and conventional planters. The method used is based on the assumption that with a given number of seedlings per hundred inches, the planter which spreads those seedlings into the greatest number of inches of row, or in other words, has the smallest number of seedlings in each beet-containing inch, is the one doing the most satisfactory planting. In other words, the planter doing the best work is the one which secures the highest per cent stand for a particular seedling stand. The number of single seedlings obtained is also used as a means of comparison. Direct comparisons between planters can only be made with the same seedling stands or seeding rates and for practical comparisons of planters curves with per cent stands and numbers of singles plotted against seedling stands must be used.

The method of comparing planters just described takes three to four weeks after planting, often longer, depending on germination and growing conditions following planting. In addition it introduces the variable of germination which is important and necessitates a number of separate counts to get a reasonably good average.

A year ago a laboratory means of testing beet planters and making comparisons of the uniformity of their seed drop was developed. It consists of pulling the planter being tested along a slightly raised runway at planting speed and with the openers down in position and catching the seed dropped on boards covered with a thin coating of light weight cup grease. The boards are set so that they are just cleared by the furrow openers, and the distance of seed drop is therefore only slightly more than it would be in field planting. The seed balls are caught and held at the exact point where they strike. Such a surface is not comparable with the narrow bottom of the opened furrow into which the seeds are dropped in the field, but it overcomes all bounce or roll of the seed and provides a means of comparison of uniformity of seed drop.

A flexible steel tape is laid down on the board alongside the row of seed dropped in each test and the longitudinal position of each seed is recorded. A run and a check run, each 200 inches, were made for each test set-up. From an original set of data sheets the frequencies of seed spacing were tabulated and a curve made up showing the percentage frequency of each seed interval observed in the tests. Such curves, with the mean seed spacing also shown, gave a graphic comparison of the seed drop of the planter. The percentage of the frequencies within a plus and minus band about the mean was used as a numerical value of comparison of the work of the planters. For our work we used the interval of plus and minus one-fourth inch from the mean. Direct compari-

sons can only be made between tests with practically the same mean seed spacing as the percentage of frequencies within the band about the mean increases for a planter as the seeding rate increases.

The averages of the data taken in a series of laboratory tests such as described above gave the following results.

The seed drop of the chain-feed single seed planter was significantly more uniform than that of the other single seed or conventional planters as a group or than any of the planters as individuals. The single seed planters as a group were significantly better than the conventional planters. There were no significant differences between the single seed planters other than the chain-feed planter nor between the conventional planters though larger numbers of test runs might show differences which were significant. On plate planters there was a tendency toward more uniform seed distribution with the single seed plates as the distance of drop decreased, but not enough for significance or near significance.

Field tests with the single seed and conventional planters show substantially the same results though the differences between the chain feed and the other single seed planters are not so marked. Seed balls undoubtedly bounce or roll around somewhat as they drop into the bottom of the opened furrow so that very uniformly spaced seed dropping into the bottom of a furrow would probably lose some of the uniformity of spacing. Furthermore, seedlings do not grow vertically from the seed balls, but rather follow paths of least resistance so that seedlings from very carefully spaced seed balls do not have the uniformity of spacing of the balls. Probably for these reasons the significant differences between the chain-feed and other single seed planters as shown by the greased board laboratory tests are less consistent and become less significant in field comparisons. We are, therefore, probably not justified in developing elaborate planting mechanisms for obtaining single seed planting.

The single seed planters as a group show significant improvement over conventional planters in uniformity of field stands and increased numbers of single seedlings. They produce the same percentage stands with slightly over 90 per cent of the amount of seed required for conventional planters, or they produce from four to five per cent greater percentage stands at the same seeding rates over the usual range of seeding rates. They also produce 20 per cent to 30 per cent more singles than conventional planters. Seeding rates of from 5 to 15 pounds per acre have been used for the tests.

The differences between most of the single seed planters are not great. The chain feed pick-up cup planter, though doing somewhat better work is more complicated, and the additional cost of its manufacture perhaps is not justified. The work of the experimental single seed planters with pick-up cup disks or wheels, as compared with horizontal plates or with vertical wheels showed no significant differences. Furthermore, a standard plate planter equipped with special single-seed plates, seed cut-off and knocker and with its normal 34-inch seed drop did practically as well as the same type of equipment in the single seed planter with its low hoppers. This means that new type planters are probably not needed for satisfactory single seed planting and that conventional plate planters equipped with the proper special equipment will be satisfactory for commercial single seed planting.

FIELD TESTS OF MECHANICAL BLOCKING AND THINNING OF SUGAR BEETS

by

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"Stoop labor" was eliminated on a nine acre field of beets at Fort Collins, Colorado in 1939. Small strips of hand raised beets were used as checks. The results indicate that it is possible to raise beets in this manner without sacrificing tonnage as compared to the customary hand labor methods. The labor requirements are encouraging in two ways, first, that the long-handled hoe method of thinning is less arduous and, second, much less time is required.

The field was laid out with several objectives in mind. The major part was planted with a commercial planter in the ordinary way. The object of this was to actually raise beets in a commercial manner without the usual stoop labor. Experimental data were desired and for this purpose replicated plots were planted making the following comparisons:

1. The single seed ball planter was compared with the commercial planter.

2. The commercial planter was used with varying amounts of seed per acre.

3. The single seed ball planter was used with varying amounts of seed per acre, (12 lbs. per acre, 9 lbs. per acre, 6.6 lbs. per acre). These variations in seeding rate resulted in distribution of seed in the row, from one seed ball to every inch of row to one seed ball to two inches of row.

4. Various methods of thinning were practiced (a) the customary method of hand thinning, (b) long-handled hoe without any subsequent hand labor, (c) the row blocker followed by the long-handled hoe, and (d) the row blocker followed by no subsequent labor. These methods of thinning were replicated and were practiced on the different methods of planting.

5. At harvest time all the plots were sampled systematically and the results are recorded.

RESULTS

1. There is no difference in yield between the beets hand thinned and those which were thinned with the long-handled hoe (no subsequent hand labor).

2. There is a significant loss in yield where the beets are mechanically thinned.

3. All germination stands were relatively poor on account of a poor germination condition in the early spring.

4. The germination stands were approximately proportional to the amount of seed used.

CONCLUSIONS

The elimination of stoop labor seems to be practicable. In the first place the yield was not decreased. There were more small beets harvested. Former tests would indicate that equal tonnage and smaller beets would give increased sugar per acre. The increased number of smaller beets would, however, multiply the difficulties in hand harvesting because of the increased number of beets to be topped. This would also be true with some methods of mechanical harvesting. It would not materially hurt the speed of mechanical harvesting when using the mechanical harvester where the beets are lifted by their tops and topped in the machine.

The quality of topping accomplished by the ground type of mechanical topper would probably be lowered because of the increased number of doubles.

In this test the labor time was not conclusive, but from former tests the time of labor involved can be estimated to be approximately one-half that of the hand method.

The single seed ball planter demonstrated its ability to increase the number of single plants with the result that thinning is an easier operation. This thinning operation is easier when done either by hand or when done by the long-handled hoe.

The single seed ball planter demonstrated the practicability of using less seed than has been customary with the standard planters.

For several years experimental work has been done on the practicability of "mechanically thinning" beets. The development came as a result of experiences with mechanically blocked beets. It was found that, with the usual mechanical blocking, there remained a large number of single beet plants. With the usual three inch block it was commonly found that twenty per cent of the blocks contained single beets.

The next step seemed logical, if the blocks were reduced to about one-third of the three inch size that there might be expected three times as many singles. The expectation was borne out. With an ordinary stand of beets and using a blocking tool leaving small blocks, we may expect about sixty singles per one hundred feet of row. This is, of course, not enough beets to make a satisfactory crop. It is then necessary to leave enough doubles to make up the usual one hundred beets per hundred feet of row, or whatever is desired.

The procedure at the present time is to have the blocking tool set to such dimensions that twice the desired number of beets are allowed to remain. Then, with a long-handled hoe, cut out sufficient bunches and closely spaced doubles that the remaining stand will give a population of approximately one hundred beets per hundred feet of row.

In the experiments this year three methods were followed:

1. The long-handled hoe was used without any subsequent hand labor.

2. The beets were thinned with a row blocker, the attempt being to leave more than the desired number of beets and then this operation was followed with the long-handled hoe.

3. The row blocker was set to thin the beets in one operation, followed with no hand labor.

These plots were replicated with a check plot of hand-thinned beets.

Naturally the mechanically thinned plots required much less labor, but this year the yield was significantly less than for the methods where the long-handled hoe was used alone.

CROSS BLOCKING OF SUGAR BEETS

by
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Blocking sugar beets mechanically by drawing a cultivator carrying special equipment across the planted rows was undertaken for the first time in Minnesota in 1929. Discs and knives were so arranged that undisturbed blocks of 4 to 5 inches were left on 16, 18 and 20 inch centers, while the balance of the beets and weeds in the row were removed.

In later years the blocks were narrowed to 3 inches and the spacing within the row reduced to 12 to 14 inches. This change resulted in a higher plant population per acre. Discs, if used at all, are now run straight and a special 5 inch knife has been designed which cuts clean and does not accumulate trash. The work is performed shortly after the seedlings emerge.

There is a saving in labor, both as to number of workers required and cost per acre. Competing beets and weeds may be eliminated early in the season and thus moisture and fertility is conserved. A beneficial mulch is left about the block and growth is retarded but little as thinning is accomplished in most instances without the use of a hoe.

Workers find that they can thin the cross blocked beets rapidly and their earnings per day are greater than when the old method is used even though the per acre rate is less. The method was particularly attractive to the grower whose beets were cared for by his own family. Fields that do not lend themselves to wire checking because of irregular borders or uneven contour may be cross blocked with success and at a saving.

HILL DROP PLANTING

The idea of a Hill Drop Planter was conceived by Joe Wartman in 1932. He proposed to accomplish the result of depositing seed at 10, 12 or 14 inch intervals in the row, saving the seed that would later grow into seedlings that would be blocked out. This first planter performed well, but it was felt that the seed was dropped too much in a clump for rapid thinning.

By 1934 at least three manufacturers were offering four and six row hill-drop planters at prices ranging from $160.00 to $230.00. The one that gained the most favor was the Rassman planter which used a rotor with cut-away spaces for depositing the seed at regular intervals. Spacings were regulated by using a variety of sizes of drive gears.

Hill-drop planting is the accepted method in 20% of the sugar beet area of Southern Minnesota. The seeding rate is between 6 and 7 lbs. per acre, resulting in a saving of approximately 2/3 of the former cost of seed. If the operator uses ordinary care and judgment in planting, skips do not occur making it difficult for a worker to justify poor work.

Workers who are willing to accept changing methods take no exception to working in the hill-drop planted fields. Their earnings per day are greater inasmuch as experience shows that they work an acre in 18% less time.

The method lends itself to rolling, irregular fields, where the check-wire planter does not perform well.

EXPERIMENTS WITH NON-THINNING OF SUGAR BEETS

by
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HARVESTING AND LOADING OF THE BEET CROP IN IOWA, SOUTHERN AND NORTHWESTERN MINNESOTA AND EASTERN NORTH DAKOTA

Our experience with cross cultivation has clearly indicated that we have increased the number of acres an adult worker can thin, and realizing that some day mechanical means will be available for reducing the number of workers needed for harvesting, which will then unbalance our seasonable labor requirements.

The first problem confronting us was to find some means whereby a planter would distribute one single seed ball at a desired spacing. After considerable correspondence with implement companies we decided, with their recommendation, to plant in a continuous row with a No. 16 John Deere planter using plate #N2469D, having 54 cells, with false plate #Y2630B and using seed graded between 9/64ths and 11/64ths in size, with a special transmission regulating the speed of the plate to drop one seed 1-1/2" to 2" apart.

A number of plots were planted with this arrangement but resulted in plants being bunched and unevenly spaced which we attributed to the light weight of the seed and height of drop, so the idea of not thinning these plots was abandoned. To overcome this difficulty we decided to try checking one seed in a hill, spacing 18 inches in the row and 18 inches between the row. By use of the check arrangement we would be able to take advantage of the lower valve which is close to the surface of the double valve arrangement in the Deere check-row planter. By reducing the 54 cell plate #N2469D to a 16 cell plate we planted 17.89 acres and cross cultivated them. The only labor used was for hoeing in August to remove the weeds at the cost of $4.00 per acre. It might be well to mention that this plot was planted two weeks later than the balance of the field which we are using for a comparison.

1938 Comparison of Average Cost per Acre of Cross Cultivated Non-thinned and Cross Cultivated Thinned, not Including Growers' Items such as Planting, Cultivating, Lifting, etc., Based on Totals of A. L. Kiel Field.

NON-THINNED		THINNED	
17.89 acres harvested, 131.4710 tons		189.72 acres harvested, 1604.9410 tons	
Average yield per acre 7.35		Average yield per acre 8.46	
Seed	.10	Seed	.95
Fertilizer	1.70	Fertilizer	1.97
Hoeing	4.00	Blocking & Thinning	9.50
Topping @ 90¢ ton	6.61	Topping @ 90¢ ton	7.61
Hauling @ 60¢ per net ton	4.42	Hauling @ 60¢ per net ton	5.08
Average cost per acre	16.83	Average cost per acre	25.11
Returns on initial advance of $4.75 per ton	34.91	Returns on initial advance of $4.75 per ton	40.18
Cost per acre	16.83	Cost per acre	25.11
DIFFERENCE PER ACRE	18.08	DIFFERENCE PER ACRE	15.07

The difference in returns between the two plots is $3.01 in favor of non-thinning.

Percentages of stand is based on 19,360 beets per acre, which represents 100% stand for an 18" x 18" spacing which applies to both plots. Percentage of stand was determined by the tareman counting the number of beets in each sample, and having the weight of the sample, we were able to compute both percent of stand and weight of beets, as follows:

Non-thinned 64.35% or 12,548 beets per acre; average weight 1.18 lbs.
Thinned 75.34% or 14,586 beets per acre; average weight 1.16 lbs.

We might add that seed planted in the non-thinned plot did not receive a mercury treatment, whereas, the field used for a comparison was treated and this may account for the difference in stand of the two fields.

In 1939 three experimental fields were planted, totaling 36.82 acres, and the same method of planting was used as referred to in our experiment of 1938. The only change made was to have a new plate #H776B made up by the John Deere Company. For brevity we have combined the three plots and our results and comparison are as follows.

Though no definite conclusions can be drawn from our limited experience we feel, as well as growers who have been observing these fields, that results justify further experiments. It appears from growers' remarks that upwards of one hundred acres will be planted and not thinned in 1940 in the Red River Valley area.

COMPARISON OF AVERAGE COST PER ACRE OF CROSS CULTIVATED NON THINNED AND CROSS CULTIVATED THINNED, NOT INCLUDING GROWERS' ITEMS SUCH AS PLANTING, CULTIVATING, LIFTING, ETC.

FIELDS BASED ON TOTALS OF KIEL, LARIVIERE AND ROSS CONTRACTS

NON-THINNED		AVERAGE COST PER ACRE	THINNED	
36.82 acres harvested			335.74 acres harvested	
Average yield per acre	9.418 tons		Average yield per acre	9.673 tons
83/100 pounds seed @ 15¢	.13		5 - 25/100 pounds seed @ 15¢	.79
65 pounds fertilizer @ $2.92 cwt.	1.90		65 pounds fertilizer @ $2.92 cwt.	1.90
Hoeing	4.00		Blocking & Thinning	9.50
Harvesting 9.42 tons per acre	8.23		Harvesting 9.67 tons per acre	8.44
Hauling @ 60¢ per net ton	5.66		Hauling @ 60¢ per net ton	5.80
TOTAL	19.92		TOTAL	26.43
AVERAGE VALUE PER ACRE @ $4.00 T.	37.67		AVERAGE VALUE PER ACRE @ $4.00 T.	38.69
DIFFERENCE PER ACRE	17.75		DIFFERENCE PER ACRE	12.26

COMPARATIVE STANDS

GROWER	ACRES HARV.	TONS HARV.	AVG. YIELD	NET WGT. SAMPLES OZ.	NUMBER BEETS IN SAMPLES	AVG. WGT. PER BEET POUNDS	ACTUAL STAND	PERCENT STAND
THINNED BEETS, Cross cultivated, 18x18 spacing, 100% stand based on 19,360 beets per acre.								
A. L. Kiel	269.84	2558	9.48	128,389	4812	1.668	11365	58.70
Chas. Lariviere	54.76	574	10.48	29,152	1133	1.61	13039	67.35
Walter Ross	11.14	116	10.44	6,976	293	1.49	14028	72.46
TOTALS	335.74	3248	9.67	164,517	6238	1.65	11739	60.64
NON-THINNED Cross cultivated, 18x18 spacing, 100% stand based on 19,360 beets per acre								
#A. L. Kiel	12.16	146	12.00	6,749	268	1.57	15247	78.76
Chas. Lariviere	11.16	87	7.83	4,533	176	1.61	9728	50.25
#Walter Ross	13.50	114	8.41	6,694	241	1.73	9688	50.04
TOTALS	36.82	347	9.42	17,976	685	1.64	11485	59.32

#The week of July 17th, an actual count of plants on each of two of these fields as follows, at the end of each 100 feet turn at a right angle, thus getting a cross section of rows. The results are as follows:

	MISSES	SINGLE PLANT TO HILL	TWO PLANTS TO HILL	THREE PLANTS TO HILL	FOUR PLANTS TO HILL	BUNCHES 5 OR MORE	TOTAL HILLS COUNTED
Hills	591	452	394	139	10	28	1614
Percent	36.62	28.01	24.41	8.61	.62	1.73	100.00

EXPERIMENTS WITH HARVESTING MACHINERY

For the past five or six years we have been working on a machine that would lift and pile the beets preparatory to topping. In 1938 we harvested 35 acres with a one row machine and had an experienced Mexican crew topping, who volunteered the statement that one-third of their time was saved in harvesting this field behind the machine. Several machines were built in 1939 but due to a short and backward season and lack of time on the part of the operators we gained little experience from this harvest though intensive work was put on one unit and some changes were made. This unit took out approximately 40 acres and desired changes indicated from this year's operations will be incorporated in the other machines. A scalping device was arranged which removed most of the tops leaving only two or three inches of the stems. This made it possible to accumulate a larger pile and tended to make it a trifle more convenient for labor. Labor topped this field for one-third less than the regular labor rates.

EXPERIMENTS WITH TRUCK LOADERS

Two different methods of loading were tried out in 1939. One, where labor topped into a low hopper which held between four and five tons of beets with a bottom conveyor driven by a power take-off which loaded the beets into the truck. The other one was a small unit with a 1-1/2 horse power engine operating an inclined conveyor with a small boot located close to the ground. This was attached to the side of the truck and moved with the truck from pile to pile. This arrangement shortened the distance a shoveler had to move the beets as it was only necessary for him to raise the beets about eight inches from the ground. Time studies and costs are lacking on both machines and further experiences and study is needed before drawing any conclusions.

CROSS CULTIVATION AND CHECK ROW SEEDING PRACTICES IN USE IN IOWA, MINNESOTA AND EASTERN NORTH DAKOTA

by

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CROSS CULTIVATION OF SUGAR BEETS

The idea of cross cultivation was instigated because it was necessary after the severe decline of sugar prices in 1929, to find some means of reducing cost of production. In the area under discussion, experimentation with cross cultivation was started in 1929 and from these experiments, it was determined that a reduction of costs could be effected, because it eliminated part of the thinning and hoeing costs. It was further found that reductions of cost could be effected without a reduction of yields. As a result, the use of this method increased steadily until at the present time, it is accepted as a standard practice in the Red River Valley area, although its use is by no means universal.

CULTURAL BENEFITS

By continued cultivations both ways, the beet field can be kept cleaner which not only reduces the cost of hoeing, but also tends to increase yields as weeds not only absorb moisture, but use much nutrition which would otherwise be available for the beet plant. Cross cultivation reduces to a minimum size, the block which the labor must work. This expedites the thinning operation and makes it possible to complete this operation before the beets get too large. It is an established fact that beets planted and thinned early produce the best yields and by the use of this method, the thinning operation is speeded up to such an extent that all of the beets can be planted at one time instead of making two or three successive plantings as is necessary under the old method.

Cross cultivation also results in a quicker recovery of the plant after the thinning operation. In the old method of blocking and thinning with a hoe, a considerable amount of dirt is taken away from the seedling, leaving the root exposed, and in hot, dry or windy weather, many of these die. Under the cross cultivation method, it is seldom necessary to use the hoe; the surplus seedlings are pulled by hand; the roots are not exposed, and this enables the plant that is left to make a quicker recovery after thinning and a smaller proportion of the stand is lost.

Cross cultivation establishes a mulch around the plant and prevents cracking of the soil which results in better conservation of moisture. In fields infested with root rot, it has been found that if the top soil is aerated by cultivation, this disease can be checked. Cultivation both ways has been found to be more effective in this regard than one way cultivation.

TYPE OF DRILL EQUIPMENT, RATE OF SEEDING AND SPACING USED

When drilling for cross cultivation, the same type of drill can be used as for old method drilling. In the area under discussion, the double disc, flutted feed type drill is most commonly used.

Eighteen to twenty pounds of seed per acre has been found best when drilling for cross cultivation. Good stands have been obtained with lower seeding rates but under adverse conditions, poor stands may result.

Various widths of spacings have been tried but studies to date indicate the 18 by 18 in. or 20 in. by 20 in. spacings to be the most practical. Several attempts at closer spacings have been tried but it is practically impossible to cross cultivate these fields the second time. The benefits of cross cultivation are, therefore, lost and no increase in yield is effected. Where six row planter and cultivators are used, the 18 by 18 in. spacing reduces the width of the machines used and this makes for better and easier handling of field equipment.

COMPARISON OF ACRES THINNED PER MAN, AND LABOR RATES, BETWEEN CROSS CULTIVATION AND OLD METHODS

By numerous tests, it has been proven that on a properly cross cultivated field, one man can thin 50% more acreage than under the old method.

Since 1932, the rate for thinning and hoeing under the cross cultivation method has been from $2.00 to $3.00 per acre less than for this same work under the old method. At the present time, this difference is $2.50 per acre.

THREE YEAR COMPARATIVE RESULTS, CROSS CULTIVATION VS. OLD METHOD
RED RIVER VALLEY AREA 1937, 1938, 1939.
COMPILED FROM RETURNS ON 59,128 ACRES HARVESTED.

METHOD	AVE. YIELD	AVE. WT. PER BEET	NO. BEETS 100% STAND	ACTUAL NO. BEETS PER ACRE	% STAND
Cross Cult.	9.62	1.55	18826	12406	65.90
Not crossed	9.44	1.45	24131	13020	53.96

TWO YEAR COMPARATIVE RESULTS, CROSS CULTIVATION VS. OLD METHOD
MASON CITY, IOWA AREA, 1938, 1939.
COMPILED FROM RETURNS ON 23,243 ACRES

Cross Cult.	10.59	2.01	17922	10573	58.99
Not Crossed	10.44	1.82	25479	11472	45.02

CHECK ROW SEEDING OF SUGAR BEETS

The first check row planter was manufactured by the John Deere Co. in 1934 and in the fall of that year, a field was planted with this machine to see whether or not it would be possible to check beets in 18 in. squares. Very good results were obtained and in 1935, the John Deere Company manufactured several more planters which were put into operation. From that time on, check row seeding of sugar beets became an established practice in the area under discussion and three different makes of planters are now being used.

The John Deere planter is a plate feed, accumulative hill-drop type with a two valve control. The valves are so timed that the seed drops from the seed plate to the upper valve and enough seed is accumulated on this valve for one hill during the interval that the machine travels from one button on the check wire to the next. During the same interval, the hill previously accumulated on the upper valve. drops to the lower valve and in the next interval is deposited from the lower valve to the soil. This machine has a stop and go clutch which controls the travel of the seed plate. Several sets of seed plates are furnished and rate of seeding can be varied by changing plates.

The Oliver check row planter is somewhat similar excepting that it does not have a stop and go clutch and the travel of the seed plate is regulated by change of sprockets. This eliminates some of the working parts and simplifies the machine. This machine is also made so that the fertilizer may be checked if desired.

Both of these planters place the seed in a compact hill, if operated at the proper speed although the Oliver planter places the seed more compactly.

The Moline check-row planter differs from the other planters in that it uses the flutted feed and has only one valve. This arrangement does not permit as low rate of seeding per acre and causes the seed to be scattered in the hill. However, this planter is much lighter and very simple in construction and if operated properly has been found to perform quite well.

All three planters have the double disc furrow openers, similar press wheel arrangements and come equipped with fertilizer attachments.

After cross cultivation became established, check row planting followed as a natural development. By the use of the check-row planter, a considerable saving in seed could be obtained and the benefits of cross cultivation still retained. Many growers were going into tractor equipment because this was found to be more efficient and more economical. This created a demand for a six row planter and as a result, most of the check-row planters were made to plant six rows.

Inasmuch as the machine companies had had considerable experience in the manufacture of check-row corn planters and the beet planters were patterned pretty much after them, the check-row beet planter was pretty well perfected when it came out and not many changes have been necessary.

At the present time, the rate of seeding with a check-row planter is about six pounds per acre. Some planting has been done with 4 pound plates, but more experimentation must be done along this line before this low rate of seeding can be recommended.

Only two spacings have been used so far in check-row seeding. These are the 20 by 20 inch and 18 by 18 inch spacings. Of these, the latter spacing is most commonly used.

THREE YEAR COMPARATIVE RESULTS, CHECK ROW VS OLD METHOD
RED RIVER VALLEY AREA. 1937, 1938, 1939.

COMPILED FROM RETURNS ON 47,838 HARVESTED ACRES

METHOD	YIELD	AVE. WT. PER BEET	NO. BEETS 100% STAND	ACTUAL NO. BEETS PER ACRE	% STAND
Check Row Cross Cult.	9.64	1.51	19360	12768	65.95
Old Method	9.44	1.45	24131	13020	53.96

TWO YEAR COMPARATIVE RESULTS, CHECK ROW VS OLD METHOD
MASON CITY, IOWA AREA, 1938 AND 1939.

COMPILED FROM RETURNS ON 22941 HARVESTED ACRES

Check Row Cross Cult.	10.71	2.02	18332	11594	63.25
Old Method	10.44	1.82	25112	11472	49.68

CONCLUSIONS

This report has dealt with the developments and results of the use of cross cultivation and check row seeding methods in Iowa, Minnesota and Eastern North Dakota and from the findings of this report, we can draw the following conclusions:

1. Cross cultivation was developed because it became necessary to find means of reducing costs.

2. A reduction of cost to the grower was effected by cross cultivation since 75% of the hoeing or weeding was eliminated and at the present time, this saving amounts to $2.50 per acre.

3. If cross cultivation is properly done, worthwhile cultural benefits are obtained.

4. The check-row planter resulted in a further savings because it reduced the amount of seed used which amounts to about $2.00 per acre at the present time.

5. In making a comparison of yields under the various methods in the Red River Valley and Mason City areas, it has been shown that beets grown under cross cultivated or check-row methods, slightly out-yield beets produced under the old method.

In conclusion, special recognition should be made of the work performed by the late C. T. Lund, who was Chief Agriculturalist of the American Crystal Sugar Company at the time, as it was largely due to his willingness to try new methods, that these methods were instigated and finally became adopted.

BASIC PRINCIPLES USED IN THE DEVELOPMENT OF AN IN-PLACE TYPE VARIABLE-CUT SUGAR BEET TOPPER

By

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The development of a satisfactory in-place topper has been attempted by many individuals and by a few organized groups. In general, efforts have been confined to the production of a finished machine with little emphasis placed on the fundamental nature of the problem. This paper will describe an investigation of some of the principles common to all in-place toppers, and an effort to apply the results to the design of a finished machine.

In-place topping consists of two essential operations. First, a gauging device must place a cutting mechanism in position to remove the proper amount of crown material from each beet. Second, the cut must be made without excessive damage to the root.

DETERMINATION OF GAUGING REQUIREMENTS

The tare charts issued by the sugar beet processing companies may be considered implied recommendations of the proper location of the topping cut. Since these recommendations are based on the location of the lowest leaf scar, it is evident that any satisfactory gauging system must make use of some dimensional characteristic of a beet which is a function of its crown thickness.

Data were taken in a number of fields in Utah, Idaho, and California under a wide variety of soil and climate conditions in an effort to discover a correlation between diameter or height and crown thickness. All measurements of height were made from a plane midway between the level of the ground adjacent to the beets and the level at the base of the furrows.

Curves representing the averages of these data are shown in Figure 1. Curve (A) shows the relation between the beet height and the greatest beet diameter. Curve (B) shows the distance above ground level of the lowest leaf scar as a function of beet diameter. In each case, the data are well represented by a straight line passing through the origin.

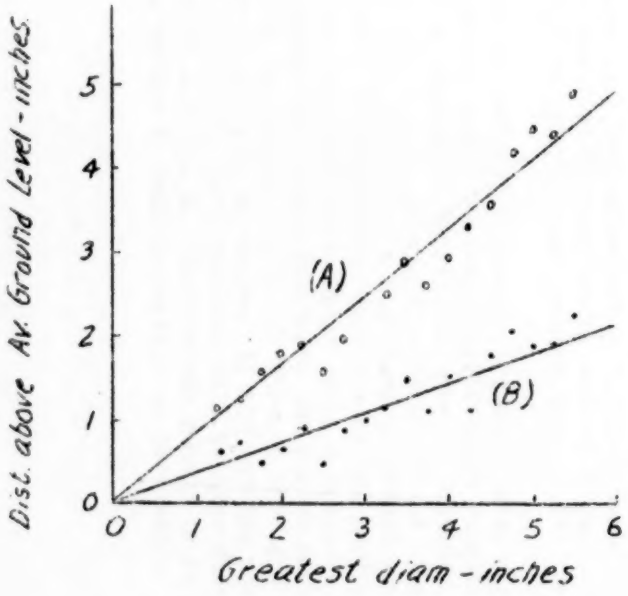


Figure 1

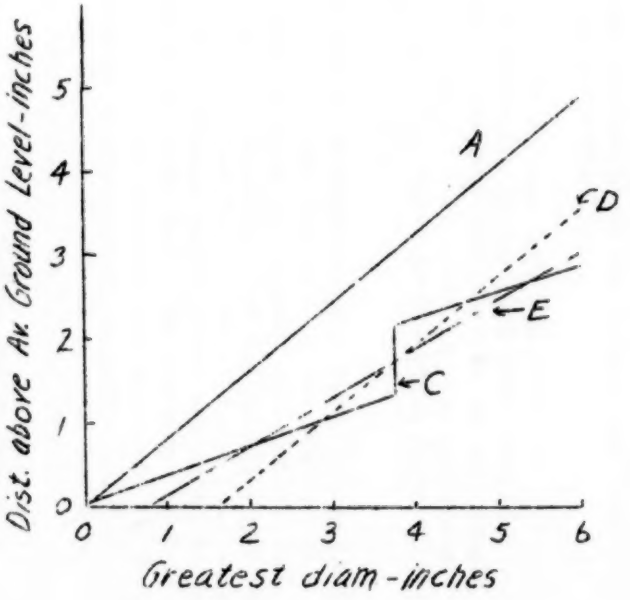


Figure 2

In the average case, the height of a beet is equal to 81 per cent of its greatest diameter, and the distance above ground level of its lowest leaf scar is 36 per cent of its greatest diameter. Since crown thickness is equal to beet height minus the height of the lowest leaf scar, it is equal to 45 per cent of the greatest diameter.

According to the average tare standards set up by the processing companies, it would be desirable to top each beet less than 3-3/4 inches in greatest diameter at the lowest leaf scar, and to top all larger beets 3/4 inches above the lowest leaf scar. This ideal topping performance is represented in Figure 2 by curve (C). This curve is the ideal locus of the topping knife for beets of different diameters.

Most experimental in-place toppers have utilized a finder which was designed to roll or slide over the tops of the beets, and a knife which was mounted a fixed distance below the finder. Evidently, such a device will remove a slice of uniform thickness from all beets, regardless of height or diameter. Since the knife and the finder rise and fall in unison, the distance of the knife above average ground level may be shown in Figure 2 as a straight line parallel to curve (A). The intercept of this performance line would vary as the machine was adjusted for different thicknesses of cut. Its estimated best position is represented by curve (D), Figure 2. Comparison with curve (C) shows that in a fixed-cut system, large beets would be topped too high and small beets would be topped too low.

The estimated best straight-line approximation of curve (C) is shown as curve (E), Figure 2. Physically, this represents a topping system in which the knife is raised 1 inch for each 1.4 inch rise of the finder. This has been called a variable-cut topping system. The thickness of the slice removed from each beet would be 0.45 inches plus 23% of the greatest beet diameter, or 0.45 inches plus 29% of the beet height. High topping of large beets and low topping of small beets would be eliminated.

The foregoing predictions of the relative performance of fixed-cut and variable-cut toppers have been substianted in field tests with machines of each type. Data have shown that topping losses and top tare in the fixed-cut system are from 50 per cent to 100 per cent greater than in the variable-cut systems.

In addition to satisfying accuracy requirements, a gauging device must be capable of adjusting itself to beets of different heights with sufficient rapidity to permit a reasonable harvesting speed. Consider the action of an in-place topper in the field. An appreciable amount of time is required for the finder to fall from the top of a high beet to ground level. Since the entire topping mechanism is progressing down row at the harvesting speed, an interval will follow each high beet during which a low beet cannot be topped. If the knife and finder are linked together, the finder cannot begin its descent until the knife has passed completely through the high beet. This causes a further increase in the skip distance. If the working parts fall through the effect of gravity alone, the skip distance will be approximately 9 inches at a harvesting speed of 2.5 m.p.h. The obvious remedy is to force the mechanism through spring action to fall as rapidly as necessary.

As the finder approaches a high beet, an opposite condition is encountered. A finite amount of time is required to raise the finder from ground level to the top of the beet. Unless a complicated relay system is used to elevate the topping mechanism, the beet must supply the raising force. Since the beet will sustain only a limited load before failure occurs, it is evident that the downward thrust on the finder must be small or the raising must be done slowly. If the former alternative is chosen, the skip distance following the beet is increased. If the latter is chosen, the skip distance preceding the beet is increased.

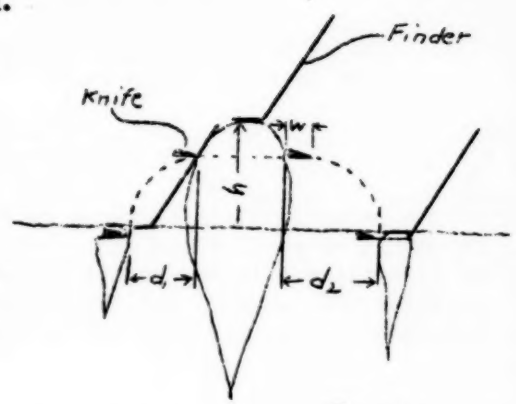


Fig. 3

Quantitative expressions describing these effects have been derived. It is found that: (refer to figure 3)

$$\frac{F_s}{W} = 1.603\, h \left(\frac{S}{d_2 - w}\right)^2 - 1 \qquad [1]$$

$$\frac{F_b}{W} = 1.603\, \frac{hS^2}{d_1^2} \left[1 + \left(\frac{d_1}{d_2 - w}\right)\right] \qquad [2]$$

where:
- F_s = Spring thrust on finder (lbs.)
- F_b = Force required to lift finder (lbs.)
- W = Total effect dynamic weight of moving parts referred to finder (lbs.)
- S = Harvesting speed (mph)
- w = Effective knife width (in.)
- h = Distance through which finder falls (in.)
- d_1 = Skip distance preceding high beet (in.)
- d_2 = Skip distance following high beet (in.)

In equations [1] and [2], h, d_1, d_2, and F_b may be regarded as field requirements whose values are subject only to limited manipulation by the machine designer. The following tentative values of these quantities have been derived from field tests and observations:

h = 6 inches (minimum)

$d_1 = d_2$ = 5 inches (maximum)

F_b = (60 lb. horizontal thrust (maximum)
) (250 lb. vertical thrust (maximum)

The variables left within the control of the designer are W, w, S, and the direction in which the lifting thrust is applied to the beet. With the other quantities fixed, the permissible effective weight will vary inversely with the square of the harvesting speed. For example, if h, d_1, d_2, and F_b have the tentative values stated above and w is 1.5 inches:

$$W = \frac{214}{s^2}$$ (if the lifting force is applied vertically to the beet)

and $$W = \frac{72.5}{s^2}$$ (if the lifting force is applied to the beet at an angle of 45°)

DETERMINATION OF CUTTING REQUIREMENTS

Most in-place toppers have used either a simple knife blade or a rotating disc to perform the cutting operation. The knife blade is light and inexpensive but has a tendency to break beets which can be eliminated only by the addition of a power-driven mechanism to support the crowns. The rotating disc cuts without breakage but is relatively heavy and requires a complicated power drive.

An oscillating knife blade has been developed in an attempt to combine the best features of the older systems. An effort has been made to correlate its performance characteristics with those of other cutting devices through laboratory tests and theoretical considerations.

The tests were made on samples 3-1/4 inches in diameter cut from beets of various diameters. A knife blade was ground to an included angle of 12° and passed through the samples at simulated harvesting speeds ranging from 1-1/2 to 3-1/2 miles per hour. Means were provided to oscillate the knife in a direction parallel to its edge at frequencies ranging from 0 to 50 cycles per second. Its stroke was adjustable from 1/4 to 3/4 inches.

The sample was so mounted as to be rigidly restrained in the harvesting direction, but free to oscillate laterally except for its own inertia. This is approximately the condition which exists in a field where the soil is light or moist. A small notch in the knife blade left a record on the cut surface of the effective lateral cutting stroke.

These formulas were found to agree with the laboratory data within the limits of experimental error.

The following conclusions may be drawn from the test data:

1. The minimum advisable frequency for an oscillating knife is 30 cycles per second.

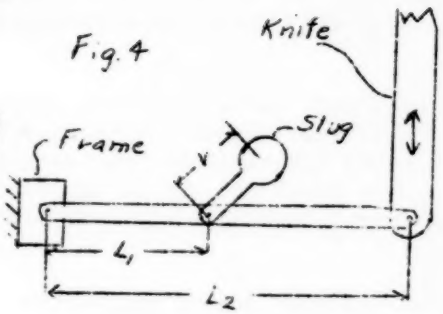
2. The down-row thrust per unit of beet diameter must be less than 7.7 lbs. per inch if breakage is to be avoided.

DESIGN OF A FIELD TOPPER

If an oscillating knife is used in the cutting operation, the necessary periodic driving force may conveniently be obtained from the reaction of a rotating, eccentrically mounted weight. Since the power requirements are moderate, the driving torque may be applied to the rotating slug through a flexible shaft. This construction reduces the number of loaded bearing surfaces to a minimum and gives freedom of motion in all directions.

Formulas have been derived to facilitate the design of a system such as the one shown in Figure 4. If there are no springs which take part in the periodic motion:

Fig. 4



$$r = 0.5 \; k \; s \left[\frac{1}{1 - \frac{s^2 f^3 W_1}{164500 P_{max}}} \right]$$

$$W_2 = \frac{W_1}{k^2} \left[\frac{164500 P_{max}}{s^2 f^3 W_1} - 1 \right]$$

where:

- r = Distance from center of rotation to center of gravity of the slug (in.)
- W_2 = Weight of rotating slug (lbs.)
- k = L_1/L_2 (see Fig. 4)
- s = Knife stroke (in.)
- f = Frequency (cycles per second)
- W_1 = Total effective dynamic weight of oscillating parts (excepting the slug) referred to the knife, (lbs.)
- P_{max} = Maximum power which can be delivered by the knife by virtue of its oscillation (hp).

Any form of rotating slug having the values of r and W_2 indicated by the formulas will fulfill the requirements. The choice of any particular shape will depend on design convenience.

The equations show that as the maximum available cutting power is increased, r becomes smaller and W_2 becomes greater. It is desirable to use the lowest value of P_{max} which will result in a satisfactory shape of slug. In any practical design, it will be found that this value of P_{max} is greater than 0.5 hp which has been found to represent the maximum cutting requirements.

Many of the problems which arise in the design of a practical in-place topper are not subject to theoretical treatment. The solution of some of these "incidental" problems is more difficult than the mere satisfaction of the fundamental requirements. These difficulties may be broken down into three principal classes: interference with working parts, wide variations from nominal field conditions, and conflicts in design requirements.

Rank foliage, weeds, seed stalks, and dried petioles tend to hamper both gauging and cutting operations. Perhaps the most serious situation is one in which large beet tops in combination with any or all of the other items form a mat ahead of the finder and prevent the topping of low beets. In the experimental topper developed in connection with this project, this difficulty was overcome by the use of a narrow finder which is centered on each beet by an auxiliary mechanism. Some new problems which will involve further study have been introduced through the use of this device, but it has been found capable of threading its way through the rankest top growth.

The use of rolling coulters to sever the dried petioles and of a conveyor mechanism to carry the tops and weeds past the working parts has eliminated clogging in all cases except where a heavy growth of wild morning glory is present.

There is no standard practice in the raising of sugar beets. Row spacing, and planting, thinning, cultivating, and irrigating procedures vary with individual tastes and requirements. A machine may be made sufficiently flexible to permit its adjustment to the average conditions in any one field without undue complication. However, variations within that field present a serious problem.

Some of the more troublesome items are: variations in row spacing, crooked rows or furrows, off-row beets, burrows of varying depth, irrigation dams and ditches, leaning beets, beets in double or other multiple combinations, and off-type beets. All of these factors except the last are under the direct control of the farmer and may be held to reasonable limits. The percentage of off-type beets is small and may be subject to further reduction in the development of seed strains.

In the experimental machine, the effects of the first three items have been minimized through the use of a straight blade knife and a self-centering finder. The disc is sensitive to these conditions because of its relatively small radius of curvature.

The performance of a fixed cut topper is not influenced by variations in furrow depth since the thickness of cut is constant. In the variable cut system, lowering the wheels has the same effect on the thickness of cut as raising the finder. In sections of a field where furrows have been deeply cut by irrigation water, beets are topped too low. Even moderately high irrigation dams result in high topping of high beets and skipping of low ones. A suggested remedy would be to design a machine in which the topping mechanism could float with respect to the wheels and adjust itself to the level of the ground adjacent to the beets. The experimental machine was not built in this way.

Leaning beets and doubles present a serious problem in any system of in-place topping. The only apparent solution is to reduce their number by improved farming methods.

In the discussion of gauging requirements, a definite relationship was shown among the harvesting speed, the skip distances, the direction in which the lifting force is applied to the beet, and the permissible weight of the topping and gauging mechanism. When an attempt is made to design a topper to operate at speeds in excess of two miles per hour, it is found that the weight of the working parts must be made very low if skip distances are to be held to desirable limits. It is difficult to design such parts with the strength and rigidity necessary to fulfill field requirements.

In the experimental machine, the working parts were purposely designed to the lower limit of strength with a view to correcting structural weaknesses as they became apparent. Liberal use was made of heat-treated alloy steels and of the aluminum alloys. The resulting structure has been found to be surprisingly fieldworthy in the limited tests which have been conducted. It now appears that its development will be in the direction of better design, with only moderate increase of weight. The total effective dynamic weight of the gauging and cutting mechanism referred to the finder is less than 5 lbs.

Whereas field tests with the experimental topper have indicated the necessity of further refinements in operating details, the results have demonstrated that the application of fundamental theory to the design of a field machine is a promising method of attack.

The force required to draw the knife through the beet would evidently reach a maximum at the center of the sample, since the width would be a maximum at this point. Means were provided to record the component in the harvesting direction of this maximum cutting thrust.

When the knife was not in oscillation, it was found that the cutting thrust was approximately 60 lbs. and was nearly independent of harvesting speed. In most cases, the knife would cut through approximately two-thirds of the sample, at which point failure of the beet would occur on a 45° plane.

When the knife was oscillated at frequencies below 17 cycles per second, the beet was found to oscillate in unison with it, so that no effective cutting stroke was obtained. The cutting thrust was the same as with a non-oscillating knife. As the frequency was raised above 17 cycles per second the inertia effects in the sample attained such proportions that a small effective stroke appeared. The effective stroke increased with frequency until, at 30 cycles per second, it was equal to the knife stroke. It was unchanged with further increase in frequcney

The cutting thrust was measured for a variety of frequencies, strokes, and harvesting speeds. It was found to increase with harvesting speed. At frequencies above 30 cycles per second it was independent of stroke and frequency but was inversely related to their product. Breakage of the samples became less serious as the cutting thrust was reduced, and did not occur at values of thrust below 25 lbs. Thrusts of 25 lbs. occurred when the ratio of the product of the stroke and frequency to the harvesting speed was 0.7.

To check and correlate the data, the following expressions for the cutting thrust were derived on theoretical grounds:

$$F = K \quad \text{(for non-oscillating knife)}$$

$$F = \frac{K}{1 + \left(\frac{v_p}{v_h}\right)^2} \quad \text{(for rotating disc)}$$

$$F = \frac{K}{\sqrt{1 + \left(\frac{v_m}{v_h}\right)^2}} \quad \text{(for oscillating knife)}$$

where:

F = Down-row thrust per unit beet diameter $\left(\frac{\text{lb.}}{\text{in.}}\right)$

K = A constant dependent on knife sharpness and beet toughness $\left(\frac{\text{lb.}}{\text{in.}}\right)$

= 18.5 lb/in. in these tests.

v_p = Peripheral velocity of disc cutter.

v_h = Harvesting speed.

v_m = Maximum value of lateral velocity of oscillating knife.

= π x stroke x frequency.

v_p, v_h, and v_m are in the same units.

SUGAR BEET HARVESTER TESTS 1938-1939

By

Roy Bainer1/

During 1938-1939, beet harvester trials were conducted in Colorado, Idaho, Utah and California. The work was carried on jointly by the United States Department of Agriculture and the California Agricultural Experiment Station, and supported in part by funds from the United States Beet Sugar Association.

The equipment tested consisted of commercial machines, farmer-built machines and machines developed at the Experiment Station. Many of the machines were not complete in the sense of doing an entire harvesting job. Some were toppers, others lifters, while in some cases the unit consisted merely of an element of an experimental machine. Most of the tests were run in California; first, because of the location of the cooperative agencies; second, because of the long harvest season, which starts in the Imperial Valley about April 15, and ends in Northern California about December 1.

Conditions in California during harvest are less favorable for machine operation than those encountered in the Intermountain States. Generally speaking, the quality of thinning is poorer, resulting in more beets in multiple combinations. Cultivation and irrigation of beets may be discontinued as much as 2 or 3 months in advance of harvest, resulting in more weeds and hard, cloddy ground. The clods, which are more numerous than beets and oftentimes much heavier, interfere with lifting and separating operations. Because of the absence of moisture the latter part of the season, top growth practically dies down, leaving a mass of dead leaves around the plant, thus hindering the operation of any machine that depends upon the leaves for lifting the beet. Experience to date indicates that any machine showing promise under California conditions should perform much better under the more favorable conditions found in the Intermountain States.

METHODS FOLLOWED IN TESTING

Toppers and Harvesters

After the machine was adjusted to do its best work, the beets and tops from 100 feet of row (usually selected in advance of machine operation) were collected for analysis. Notations were made of stand, variations in height and arrangement, such as multiple combinations.

The topping loss, due to topping the beet too low, was determined, by trimming from the crown, any portion that should have been left on the beet.

The beets were segregated into two classifications: those commercially acceptable and those commercially unacceptable. This was an arbitrary classification based upon the amount of leaves left on the beets. The beets thrown into the unacceptable group showed no signs of any cut through the crown, but in the majority of cases the leaves had been cut or pinched off.

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The beets were then trimmed for top tare. The tare was measured and recorded separately for each group, then added to make up the final report. Beets up to 3 inches in diameter were cut squarely at the leaf scar while those larger were cut 3/4 inches above the lowest leaf scar, then trimmed at approximately a 60 degree angle. Beets less than 1-1/4 inches in diameter were thrown out. Topping loss and tare were then added to give an index for rating machines.

In order to have something tangible with which to compare harvester tests, a test was made to determine the tare for an ideal job of hand topping. The beets were carefully topped with one straight cut across the beet at the leaf scar on 3 inch diameter or less beets, and 3/4 inches above the leaf scar on larger beets. In no cases were the beets topped in a manner to make them commercially unacceptable. The tare on these samples amounted to 3.03 per cent.

Checks were made of hand topping in California, Colorado and Idaho. A weighted average showed a topping loss of 1.83 per cent and top tare of 2.7 per cent. The sum of the two amounted to 4.53 per cent.

Machine Descriptions

Following is a description of the machines tested.

Scott-Urschel. This machine was developed by W. E. Urschel for the Scott-Viner Co. It consists of a single row, pulled type machine, operated through a power take-off from a 25 or 30 horsepower tractor. A pair of rubber-faced elevator chains grasp the beet top just as a single-point type plow, operating under the row, loosens the beet. The beets are elevated by their tops to a set of horizontal roller bars which position the beet for topping. A pair of rotating concave disks, set at an angle with each other to give a roof-like cut, do the topping. The tops may be windrowed or piled, while the topped beets are elevated directly to a truck or hopper.

The Scott-Urschel machine is no doubt the closest approach to a complete mechanical harvester available at this time. However, its operation depends upon adequate beet tops for lifting. The gathering points lack flexibility in getting over beets of uneven height. The method of gauging follows practically a straight relationship which means that if the machine is set to properly top average beets, too much material will be removed from small beets. The machine has the definite advantage of separating beets from the soil, saving tops and handling beets in multiple combinations. By following the machine with one or two men to pick up missed beets and trim improperly topped beets, the machine is able to do commercial harvesting.

Variable-Cut Topper. The Variable-Cut topper being developed at the California Experiment Station is still in the experimental stage. Its design is based upon data taken in California, Idaho and Utah, which show a definite correlation between thickness of crown and the height a beet grows above the ground. The machine is constructed with a ratio linkage connection between the finder and the knife so that a thicker crown cut is taken from a high beet than from a low one. The thickness of the cut is ganged by a self-centering finder as it passes over each beet. The topping is done by a flat vibrating knife, operated by a reaction drive mounted on one of the knife arms. This unique drive consists of an off-center slug rotated at 3000 revolutions per minute (field speed 3 miles per hour) by a flexible shaft connection to a gear box, driven from the ground wheels. The slug sets up a 100-pound lateral force on the knife and causes it to oscillate through 3/4 inch lateral strokes 100 times per second.

The flexible drive allows for quick raising and lowering of the knife without affecting its operation, and provides sufficient energy to force it underground. The unit is made light purposely to allow the finder and knife to be spring-loaded to hasten acceleration downward when passing from a high to a low beet.

The satisfactory performance of this unit depends upon the arrangement of beets in the field. For conditions of fairly uniform spacing, and with not to exceed 10 to 15 per cent of the beets in multiple combinations, the machine will do work comparable with hand topping. Where two beets of uneven height are growing together, the high one will be topped correctly, while the other will be missed or improperly topped. Due to its extreme flexibility and the rapidity with which the topping mechanism falls from a high beet, forward speeds up to 3 miles per hour are possible.

Devey Topper. This unit consists of a driven tandem wheel-type finder and a cutting disk for removing the crown. Each finder wheel or roll consists of four 6-inch flat disks, made of 1/2 inch steel plate, set 1-3/4 inches apart. One wheel dove-tails with the other to give a more continuous surface against the beet. The front roll is mounted about 3 inches higher than the back one to facilitate getting over high beets. The actual gauging is done by the back roll. An ordinary 16 inch or 18 inch disk harrow blade is used for the topping knife. The disk blade is driven at approximately 225 revolutions per minute. A short length of chain operating on a sprocket on the disk drive shaft and an idler sprocket, brushes the beet tops to one side as they are cut off. An adjustable linkage connection between the frame supporting the finder and the disk support makes it possible to change the relative position of the two to cut more or less crown from the beet. At the same time it provides a means for giving a ratio between the finder and the disk, in order to take a greater cut from a high beet than a low one. The machine, when tested had a variable cut ratio of 1.25 to 1. As many as four units may be mounted on the tool bar of a general purpose tractor, and driven from its power take-off.

The chief disadvantage of this type of design is excessive weight. The only possibility of spring loading the unit for accelerating its downward movement, is to reduce its weight considerably; otherwise, the beet is unable to withstand the force on it. The only alternative is to operate at low field speeds. During tests, the machine was operated at approximately 1.25 miles per hour. In one case where the beets were extremely high the machine was slowed down to 3/4 mile per hour to avoid skipping beets.

The wide roll finder made it possible to keep the topping loss low. There was no opportunity for the finder to slip off the beets, or pass between doubles, either of which would allow the knife to take an excessive cut. The machine also handles weedy conditions very well. Topping was satisfactorily done in a field badly infested with morning glory. Under heavy top growth conditions, some difficulty was experienced in getting through the top growth to low beets. Otherwise, the tops did not interfere with proper gauging.

Liberty Topper. This unit is mounted on the tongue of a horse-drawn lifter, so that the beets are topped just ahead of plowing. The gauging is done with a single blade-type finder which is made integral with the knife. The finder is sharpened on the under side so that it actually cuts into the top, splitting the crown just as the horizontal knife cuts it off. The knife consisting of two wings, set at an angle with the direction of travel, closely resembles the blades on the shovel of a duckfoot cultivator. Flat runners, on each side of the finder, tend to center it on the beet. The depth of cut is regulated by the

relative height of the finder above the knife. This method of gauging, although simple, does not compensate for high and low beets. Under the dry soil conditions at Davis, the knife would not enter the ground, so that beets with crowns below the surface were not topped. However, this type of knife was employed on two toppers designed for use in peat soil.

John Zuckerman Topper. This topper consists of a 4-row self-propelled unit. Beets are topped in the ground by a "V" knife similar to the one used on the Liberty. A positively-driven pair of narrow-gauge wheels holds the beets in place while they are being topped. The machine employs a direct gauging ratio so that approximately the same cut is taken on each beet regardless of size. The tops are raked to one side by a side delivery rake.

Roscoe Zuckerman Topper. This machine differs from the John Zuckerman unit in that the gauge wheels are ground-driven and a variable ratio (1.1 to 1.4 to 1) was built in to compensate for high and low beets. The machine is of the pulled type. The preliminary trials with this machine were not satisfactory since the wheels tended to sink into the loose peat soil, and the whole machine rocked about its single axle.

Great Western Topper. This unit was developed by the Great Western Sugar Company several years ago. It tops 2 rows and consists of a positively driven wheel-finder with a horizontal knife attached immediately below it. The cut is fixed so that all beets are topped alike regardless of size. The finder wheel holds the top in place while the knife cuts through, which reduces the tendency toward breaking the beets. A side delivery rake attached to the topper moves the tops laterally, away from the two rows.

Lifters and Diggers

Topping beets satisfactorily, while in the ground, is only one step in the harvesting problem. An equally difficult task is that of lifting topped beets from the soil and separating them from clods. Ordinary lifters do not raise the beets sufficiently to be seen. Therefore, they cannot be picked up by hand without loss. Clod conditions found in California, and occasionally in the Intermountain States, prevent the use of machines that lift the beets and surrounding soil and then attempt to separate them on screens.

Many attempts have been made to build lifters, and, in some cases these have met local conditions. A brief discussion of some of these lifters follows:

John Zuckerman Digger Loader. Four rows of ground topped beets are picked up by means of spiked wheels. The wheels are approximately 3 feet in diameter. Each has four rows of spring-loaded sharpened spikes 5/16 inch in diameter, protruding 3 inches from the surface. The beets are loosened by conventional winged type subsoil plows ahead of the wheel. As the wheel rolls over the beets they are pierced by the spikes and carried to the stripper. They fall from the stripper to a cross conveyor and elevator which loads them into a truck. This unit worked on a commercial basis in peat soils. It should have had something like a Rienks roll screen in it to remove the surplus soil. Approximately 500 pounds of soil were loaded with each 8000 pounds of beets. The spikes, being radial to the wheel, change position while entering the beet. This does not bother so much where beets are grown in peat soils because the beets are loosely held by the soil and they can line up with the spikes. In sedimentary soils this is not true; therefore, more breaking of beets occurs. Approximately 20,000 tons of topped beets were handled in 1939 with this machine.

Roscoe Zuckerman Digger Loader. A four-row potato digger, developed for peat soil conditions, was rebuilt to handle beets. Conventional double blade lifters backed up by a lugged conveyor and potato chains loosen the beets and elevate them with the peat soil to a high-speed Rienks roll screen. The beets are bounced by the screen so that most of the dirt is removed and sifted out. They are then elevated to a truck which backs along behind the digger-loader. This unit will not work under sedimentary soil conditions. Zuckerman harvested on a commercial basis this year in peat soils using this topper and loader.

Devey Digger. Devey employs a bed type lifter that straddles two rows of beets. Rods extending back and up from the plow points guide the beets and soil to two transverse, horizontal square rods immediately behind the standards. The square rods are 6 inches apart and are equipped with picker fingers. They are driven so that the top of the rods rotate away from the plow. As the soil mass and beets move backward relative to the plow, the rods assist in maintaining an even flow. At the same time the picking fingers engage the beets, lifting them to the surface. A subsequent mechanical pickup operation has not been developed.

Braden Lifter. The Braden lifter consists of a double blade plow having long blades, which loosens the beets and elevates them into a moving "V" shaped elevator. The elevator is made of potato chain and extends from the plow points to a dump hopper at the rear. This machine works satisfactorily only if the soil is loose and friable. The open elevator permits loose soil and small clods to fall out as the beets are conveyed to the receiving hopper, which may be dumped when full. An extension on the elevators would make it possible to load directly into a truck in cases where dirt is satisfactorily removed.

Experimental Vibrator Lifter. A brief description of a rather novel elemental vibrating device for lifting topped beets to the soil surface may be of interest. It is necessary to point out, that most of these experimental devices are quite crude in their early development, but they illustrate possible methods of attack, and demonstrate principles, which in time may have practical significance in lifting beets and subsequently separating them from clods. The Vibrating unit consists of two horizontal rods joined to form a "V" with the open end extending in the direction of travel. The "V" is carried by four vertical supports which are driven by counterbalanced cranks. A small engine drives the cranks at 1500 revolutions per minute. The throw of the cranks is 1/2 inch, which gives a lifting stroke of 1 inch for each revolution. The unit is preceded by a double pointed plow for loosening the beets. The "V" engages the beet just below its bulge. Its action is first that of breaking up the soil adjacent to the beet; and secondly, raising the beet by successive short lifts. The beet is contacted as soon as the space between the rods is equal to the diameter of the beet, which means that as the machine is pulled forward along the row, each beet is contacted, regardless of size. Several preliminary runs have been made with this elemental device. All of the beets in the row were lifted to the surface and at the same time the clods were considerably reduced in size. Some of the tap roots were broken, due to lack of clearance and design of the "V". However, the experimental unit shows promise in its ability to lift beets free of clods. Further development work, making use of these principles, is in progress at the California Experiment Station.

Hand Topping into Mechanical Loaders

Two of these loader units were built and used in California the past season. One was built by Frank Alvos of Buttonwillow, California, the other by J. P. Rapetti, of West Sacramento, California. The latter only will be described.

The Rapetti Loader. This unit is built around the chassis of a Holt "45" tractor. A cross draper made of old belting 18 inches wide spans 11 beet rows (20 inch spacing). A cleated elevator, consisting of another length of belt, carries the beets from the conveyor into a bin. The back stop on the cross conveyor is interchangeable from one side to the other. This was necessary to operate the machine in either direction. This latter feature eliminated the necessity for turning completely at the end of the field. Power for driving the tracks, cross draper and elevator is furnished by an automobile engine. An auxiliary transmission between the engine and the final tractor drive makes it possible to operate the machine in either direction at approximately 1000 feet per hour. Topping is done by 8 men working on 12 rows. Two men top from 3 rows, throwing the topped beets onto the cross conveyor for loading. The bin over the chassis has a beet capacity of approximately 4 tons. The trucks used for hauling carried 8 tons per trip, so that 2 bin loads were required to make one truck load.

A summary of a field test on the machine follows:

Area of test plot (acres)	0.47
Yield on test plot (tons per acre)	16.8
Speed of topping and loading (miles per hour)	0.17
Area covered topping and loading (acres per hour)	0.41
Rate of topping and loading (tons per hour)	6.88
Beets per hundred feet of row (number)	109
Number of rows topped	12
Acres per worker -- per hour	0.04
Tons per worker -- per hour	0.69

Crew: 8 toppers
1 operator
1 man placing beets in bin. (Better design would eliminate this man.)

The time for transferring beets from the bin to the truck was 3-1/2 minutes. The same length of time was required for turning the machine at the end. The time for unloading could be eliminated by transferring beets without stopping the machine. The turning time could be reduced by providing a gear change for speeding up the machine at the end of the field. The lost time in turning once and transferring 8 tons to a truck cost the grower, in wages, $0.87 or approximately $0.11 per ton. The time lost, however, might be charged to rest periods. The labor cost for topping and loading a 16.8 ton crop with Rapetti's loader totaled $12.23 per acre. At the present rate, the cost for hand topping and loading, in the same area, would be $14.38. The labor saving amounted to $2.15 or 16 per cent reduction below the cost for hand work. This does not take into consideration machine costs.

Loading Hand Topped Vs. Machine Topped Beets.

A comparative test was run with the Alvos loader (similar to the Rapetti) in which beets were hand topped and loaded in one case; and in another machine topped beets, plowed with the ordinary beet lifter, were loaded by hand. The rate of loading, in the latter case, was twice that when the topping was done by hand. However, difficulty was experienced in finding topped beets. This practice would not be practical unless the beets were brought to surface visibility in the lifting operation.

Other Machines

Pueblo Harvester. The Pueblo harvester is a single-row unit. Untopped beets are pulled by means of a lifter of the double-blade type equipped with extension rods, and then elevated by means of a slatted draper to a sorting conveyor. The beets are picked from the conveyor by hand and fed into circular topping saws. The topped beets are then elevated to a hopper from which they are dumped in piles, while the tops pass through the machine on the conveyor and fall to the ground. Under California conditions a considerable amount of dirt was elevated with the untopped beets and this was mixed with the tops by the time they had reached the ground. Power for operating the machine as well as pulling it in the field was furnished by a 14 horsepower row-crop tractor. Considerable difficulty was experienced in keeping the machine on the row. This was partially due to an offset hitch on the overloaded tractor, and to the fact that there was no provision for steering the machine other than through the tractor.

Four operators were used; two picking untopped beets off the conveyor and laying them on cleated belts to feed the topping saws; and two positioning beets into the topping saws as well as picking up beets missed by the other workers. A tractor driver was required. At the rate traveled (1.06 miles per hour), 25.8 man-hours were required to lift, top and pile an acre of beets (24.6 tons). This is 28 per cent greater than the labor required to lift, top and windrow the same tonnage by hand under the same conditions. The topping knives on this machine are quite hazardous. They could not be adequately shielded because of the nature of the work. Operators had to be extremely cautious not to get their hands into the knives because of the unsteady footing furnished by the moving machine.

American Crystal-Oliver Buncher Loader: A discussion of this machine will be omitted since it is being covered in another paper.

Summary

Typical test runs made on several different harvesters are reported in Table I. The Scott-Viner and Pueblo are the only complete harvesters in the group. The others are "in place" toppers only.

The tare on the beets in run 4 amounted to only 1.6 per cent at the factory. Large beets were not tared to 3/4 inches above leaf scar by this company. Beets left in the field, run 5, amounted to 3 per cent by number. Run 6 was made in machine-thinned beets. In run 7 the factory tare (Colorado Standard) was 8.6 per cent. The field loss in run 8 amounted to 4.2 per cent which was partially due to horizontally-growing tops. While many beets in run 9 were judged unacceptable, the tare on these amounted to only 6.7 per cent.

The quality of work done by the variable-cut unit, runs 10 to 16, was rather consistent in each state where tests were made.

Run 17 is the average for 5 runs made with the Devey topper under very favorable conditions.

Runs 18 and 19 were made in a field badly infested with morning glory. The operation of the machine was not influenced by the heavy weed growth. No trouble was experienced with vines winding on the revolving parts. The beets in this field were quite large. Several beets in the test row weighed 12 to 15 pounds, with one weighing 24 pounds. In other words, these runs show performance under rather adverse conditions.

The field in which run 20 was made had a very heavy growth of tops with "pineapple" crowns. Many were 6 inches and 7 inches above the ground. Some difficulty was experienced in getting through the top growth and topping the low beet correctly. The heavy growth did not interfere with the gauging of the beets that had grown high above the ground. Speed had to be dropped to 3/4 mile per hour to allow time for the topping unit to fall from high beets. Factory tare amounted to 5.72 per cent.

Both Zuckerman machines, runs 21 and 22, were designed for operation in peat soils. John Zuckerman reported an average factory tare of approximately 4 per cent.

Run 23 represents the best performance rather than the average for this machine (3 runs). The operators knew that tests were being run so they did their best. The field loss amounted to 1.81 per cent.

TABLE I

SUMMARY OF BEET HARVESTER TRIALS 1938-39

Run	Machine	Location	Speed mph	Stand	Yield T/A	Acceptably topped % by wt.	Top Tare %	Top Loss %	Combined Tare and Top Loss
1	Liberty	Calif.	2.1	107	22	74.4	7.7	1.7	9.4
2	"	Utah	2.0	70	23.5	65.4	2.85	2.76	5.61
3	Gr.West.	Calif.	2.1	107	22	89.2	5.8	2.2	8.0
4	Scott-Urschel	"	2.05	96	22.5	100.0	2.63	0.92	3.55
5	"	"	2.94	94	25.5	95.98	2.76	1.54	4.3
6	"	Colo.	2.29	102	10.4	98.56	4.28	3.30	7.58
7	"	"	2.31	84	18.2	94.0	4.87	1.11	5.98
8	"	Idaho	1.80	93	20.6	86.2	3.46	1.03	4.49
9	"	"	2.0	95	28.3	74.7	3.30	1.94	5.24
10	Variable-Cut	Calif.	2.9	110	14.8	97.12	1.6	2.4	4.0
11	"	"	2.75	95	17.7	100.0	3.4	0.62	4.02
12	"	"	2.8	91	21.2	96.74	2.3	2.16	4.46
13	"	Colo.	2.75	102	10.4	99.46	2.5	0.96	3.46
14	"	"	2.75	84	18.2	99.86	3.2	0.68	3.88
15	"	Idaho	2.75	93	20.6	99.37	2.1	1.93	4.03
16	"	"	2.75	95	28.3	98.63	1.5	1.71	3.21
17	Devoy	Calif.	1.25	93	27.3	97.7	4.14	0.30	4.44
18	"	"	1.26	86	26.7	95.8	2.47	0.10	2.57
19	"	"	1.20	93	45.4	95.5	4.70	0.11	4.81
20	"	"	0.77	127	44.0	92.4	5.14	0.48	5.62
21	Roscoe Zuckerman	"	1.87	127	23.8	94.5	2.35	5.06	7.41
22	John Zuckerman	"	2.25	88	23.0	90.6	8.25	1.34	9.59
23	Pueblo	"	1.06	103	24.6	100.0	1.13	1.14	2.27

SUGAR BEET SEED THRESHER AND CLEANING EQUIPMENT

H. W. Bockstahler and Ralph F. Seamans[1/]

(Cooperative investigations with the American Crystal Sugar Company)

Machines constructed at Rocky Ford, Colo. for threshing and cleaning the relatively small lots of sugar-beet seed as obtained in sugar-beet breeding investigations were demonstrated, as follows:

(1) Combined thresher and cleaner. This machine was devised to thresh and clean seed of individual sugar-beet plants, or small group of plants, at one handling. The outfit as devised removes the seed from the stalks by means of a rotating cylinder equipped with teeth; the seed is screened through a coarse-meshed screen onto the draper; the draper removes leaf trash and small

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pieces of seed stalk, the principle of separation being that the seed balls bounce and roll down the rotating canvas band of the draper as the sticks and trash are carried over the top of the draper band.

(2) Suction seed separator. In this apparatus, the draft from a suction-sweeper fan is utilized to elevate the sugar-beet seed and discharge it slowly in the separation chamber into an upward air draft which carries light seed to a hopper at the top of the machine, the heavier seed falling into a hopper at the base of the separation chamber. The draft is adjustable and a sample of seed can be run repeatedly through the machine with varying degrees of updraft in order to obtain the type of separation desired.

(3) Polisher for sugar-beet seed. A machine was devised to remove excess corky tissue from the seed balls and to crush light, empty seed balls. It consists essentially of (1) a helicoid feed mechanism to advance the seed from the hopper into a cylindrical chamber, and (2) a control shaft which runs the long way of the cylindrical chamber and which can be rotated slowly. The shaft is studded sparsely with peg-like teeth. As the shaft rotates, the seed balls within the chamber are ground against each other. The polished seed balls spill out of the end of the cylindrical chamber, the rate of movement being governed by the elevation angle given the cylindrical chamber.

(4) A wind blast, single-screen fanning machine for sugar-beet seed. A machine of simple construction consisting of a hopper, shaking screen, and wide paddle fan to furnish the wind blast has been devised to handle larger quantities of sugar-beet seed for which a primary, rough separation following threshing is desired. As the seeds and stems emerge from the hopper and move along the screen, the wind blast (subject to control) from the fan is introduced under the screen near the hopper feed. The larger stems tend to remain flat on the screen until they are discharged at the open end. The seed and short stems fall through the screen onto a sloped trough. The trough serves not only to collect the seed but serves to encase the shaking screen and direct the air blast.

Section F. Chemical - Chairman: H. W. Dahlberg

SULPHITES IN SUGAR HOUSE PRODUCTS

Origin and Control

F. S. Ingalls

The study of sulphites in sugar house products has been one of rather wide scope extending into each unit of the Utah-Idaho Sugar Company's group of factories. Organization members from each has contributed toward the general survey.

The initial investigation consisted merely of the determination of the sulphites in the granulated output at each factory using the method of direct titration with standard iodine into 100 gms. sugar dissolved in 150 ml. freshly boiled and cooled distilled water. Inorganic SO_2 only was considered and the total iodine absorbed was calculated to SO_2. Results from the initial survey showed wide differences in the SO_2 saturation of our granulated sugar not only as between plants but also as between strikes at the same plant, reaching a high of 170 ppm. and a low of 35 ppm. One plant however, produced sugar generally falling in the lower bracket while from another the granulated carried saturations within the higher ranges. Thus, we had two plants operating according to the recognized standards of the day, yet producing sugar strikingly different insofar as the sulphite sulphur content of the product was concerned.

Growing interest in control of the sulphites prompted further study with respect to source and probable quantities of the salt. Survey was commenced covering the battery supply water, kiln gas, 1st and 2nd carbonation juices, thin juices, thick liquors and massecuite. The SO_2 determination of materials up to the thin liquor failed to reveal SO_2 in any quantity. However, the thin liquor in all cases carried a relatively heavy saturation of SO_2, pointing definitely to the fact that presence of sulphites in the liquors is directly traceable to use of sulphur dioxide in the process of manufacture.

Samples of thin liquor were collected from seven of the operating factories and immediately analyzed. Determinations for SO_2 were made by distillation following the scheme described under "Official Method - Association of Official Agricultural Chemists." Results from analyses of the juice collected showed a relationship between pH and degree of SO_2 saturation. In general, the degree of SO_2 saturation varied inversely with the pH, although a lack of correlation between the two lead us to suspect a satisfactory control of the sulphites would involve regulation over the juices even before the addition of sulphur dioxide.

The next step in our investigation involved study of effect from changes in lime addition per cent on beets, alkalinity of the first carbonation juice, pH of second carbonation juice, pH and SO_2 saturation of the thin liquor. Changes in lime addition where batch carbonation was employed appeared to be a factor; with all other values constant, sulphites in the granulated were found to be in the lower regions when the lime addition exceeded 2.4% CaO on beets. Alkalinity of the first carbonation juice, when held within the

limits necessary for proper filtration and normal colors, is definitely not a sulphite control feature.

During carefully regulated periods in which pH of 2nd carb. was varied and pH of thin juice held within narrow limits, the SO_2 saturation of the thin juice followed much more closely pH of the thin juice than during any previous survey.

This study was followed by one arranged to determine a desirable combination between pH of second carb. and pH of thin juice, with second carb. pH running from 8.6 to 9.0 and thin juice pH running from 7.4 to 8.6. From data assembled during the study, it appeared that SO_2 concentration of the thin juice reached its maximum when a relatively high pH second carb. was sulphured to 7.4 pH, 7.4 pH at this time being designated as the low point in the tolerant limits for thin juice. The minimum SO_2 saturation was obtained as a relatively high pH second carb. was sulphured to 8.6 pH.

Selecting from the lot of tests a group where the pH drop was constant at .4 second carb. pH running from 8.6 to 9.0 and thin juice pH from 7.4 to 8.6, the lowest thin juice saturation followed the sulphitation of 8.8 pH second carb. to 8.4 thin juice. Sulphitation of 9.0 pH second carb. to 8.5 pH thin juice, showed a somewhat higher SO_2 saturation of the thin juice than did the 8.8 – 8.4 combination.

Control of the thin juice pH to measurements falling within the region above 8.4 was at first viewed with some concern, particularly respecting effect on the sugar and simple syrup colors. However, colors have been generally better since higher pH controls were established, although no claim is made that higher pH were instruments in the improvement of colors, since several other process refinements have been put into force during the past few years.

Quoting values from our 1939 General Laboratory Report, sulphites in the granulated sugar from the factory during which the time of initial survey showed sulphite concentration up to 170 ppm. now show an average sulphite of 7.7 and sulphites in the sugar from the factory formerly showing 35 ppm. now show an average to date of 4.9. Other factories of the group are showing generally low sulphites with periods wherein the saturation reaches one and two ppm.

Conclusion: Always assuming sufficient lime addition and first carbonation manipulations of character to provide desired reactions within the first carb. tanks, we have found that further carbonation during the second stage preceded by heat on the high alkalinity side and carbonated to a pH of 8.8-9.0, followed by SO_2 saturation to pH of 8.4-8.6, will provide thin juice from which sugar of relatively low SO_2 content may be expected.

In closing, acknowledgement is made for the many helpful suggestions offered from the Bureau of Agricultural Chemistry and Engineering through Mr. J. C. Keane who was associated with the Division at the time our survey commenced.

SUGAR LOSSES IN BEETS IN STORAGE

R. J. Smith
Holly Sugar Corporation

I feel it is in order to make a few preliminary remarks regarding points in connection with the procedure and results of test work involved in determining sugar losses in storage beets.

There is a loss of sugar in beets during storage regardless of conditions under which they are stored, for during the life of the beet, its sugar is being used for respiration purposes.

Sugar losses are greater for longer periods of storage and where higher temperatures are encountered. According to experimental results by Dr. Classen, the temperature of beets in piles is higher than that of the surrounding air. This is one point on which we have no data on our test work. With the higher piles of the present, there should not be the radical temperature changes throughout the pile that would prevail in low piles.

In the earlier days of the Beet Sugar Industry, methods of storage consisted mostly of storing in beet sheds of large capacity or in low piles where, in the latter case, the area exposed to the elements was very great. Tests were made to determine the extent of the loss of sugar during the storage period, and reports of earlier tests, by others, show sugar loss of beets in sheds to be greater than in piles and as a result, shed storage is now usually kept at a minimum.

In more recent years there have been numerous developments and improvements in methods of harvesting, receiving, and storing. At the present time harvesting can be completed much more rapidly with facilities for receiving and storing being geared up to keep pace with faster deliveries.

The problem of storing is still a major one as larger tonnages are now in storage, part of which were formerly undelivered by the growers until a later date.

Handling equipment has been greatly improved so beets enter storage with much less foreign material, which is one cause of deterioration, and the surface exposure per ton in storage is greatly reduced because of the large increase in depth of pile.

Since under present conditions, harvest can be, and normally is, finished in a shorter period of time, it permits delay in start of deliveries with lengthening of the growing season tending to increase sugar content, and make a more mature beet that should hold up better in storage.

In order to determine sugar losses under present methods of storing it was decided to make tests using a rather simple system and one which it was believed would give fairly accurate and representative results. We are not aware of the previous use of this method of storing by means of "what may be termed the 'basket system' ".

No attempt was made to choose samples for these tests but instead they were taken as they came from the general run of beets as delivered.

The procedure was as follows:

1. A sample of 100 beets was taken from a load delivered at the factory receiving station just before the load was dumped into the piler hopper.

2. This large sample was divided into two samples of 50 beets each by picking alternate beets, one lot to be placed in the storage pile, the other for immediate testing.

3. One sample was carefully cleaned, avoiding any damage to beets, then placed in a basket made of fine mesh wire. This permitted free circulation of air and lessened the chance for loss of small pieces of beets that might be broken off. The sample was then weighed and a tag was attached showing Sample Number, Date and Weight. The basket of beets was then located in the pile with a marker placed on top of the pile and above the sample.

4. Samples were located in the pile near the bottom, center, and top and so distributed as to represent average conditions throughout the pile as closely as possible.

5. The duplicate sample was at once taken to the laboratory where the beets were carefully cleaned, weighed, each beet quartered, one quarter of each beet saved and the quarters composited. This composite sample was then passed through a cossette grinder and the ground beets thoroly mixed. Determinations were made in duplicate for moisture, sugar content, and for purity. These results were for later comparison with those of the duplicate sample which had been placed in the storage pile.

6. As beets were being sliced from the storage pile, the sample baskets were removed as soon as exposed. They were taken at once to the laboratory, weighed, the beets quartered, ground and carefully mixed. Duplicate determinations were made for moisture, sugar content and purity for comparisons with the other half of the sample taken at the time the beets went into the pile.

Many baskets of beets were placed in storage piles that were damaged by shovels when beets were being removed for slicing. These were a total loss for test purposes and only results of tests of beets in undamaged baskets were used in compiling the data included in this paper.

Results of tests on Samples at Factories No. 2 and No. 5 show a substantial decrease in sugar content of samples of Beets Out of Pile from those Into Pile, also the higher Sugar Loss in samples at those two factories. In the case of both these factories, adverse weather conditions prevailed during a considerable part of both harvest and storage periods. There was greater variation in Sugar Loss between individual samples at these two factories than at any of the others involved in this test work.

"Moisture Loss % on Beets + Sugar Loss % on Beets" is a figure obtained fron analytical results and was calculated for comparison with actual % Weight Shrink in these samples. The results check very closely.

Results of tests for the first year series show an average of .49 lbs. sugar lost per ton beets per storage day. For the second year series the average is .50 lbs. per ton per storage day.

First Year Series

Factory 1. This was a shovel pile approximately 7 feet in depth. The samples went into and came out of the pile in fine condition and weather was good during the storage period. Samples averaged 42 days in this pile with a sugar loss of .25 lb. per ton beets per storage day.

Factory 2. This was a Piler pile and most samples placed in the pile were in good condition. About one half were removed in good shape with part of the balance being fair and the remainder badly decomposed. There was considerable snow fall after the middle of October and generally very low temperatures from November 15th to the close of run on the first of the year.

Average number of days samples were in storage was 38, with a sugar loss per ton per day of .76 lbs.

Factory 3. The samples were planted in good condition in a Piler pile but came out with some slight mold and rot after being in storage an average of 25 days. The loss of sugar per ton per day averaged .24 lbs. with fair dry weather prevailing during the period of storage.

Factory 4. Samples were placed in both Piler and Shovel piles, the beets in good condition. Weather was good during the storage period. Approximately 50% of the samples were removed from storage in good condition with the remainder showing slight mold. Samples averaged 38 days in the piles with a sugar loss of .29 lbs. per ton per day.

Factory 5. The samples into Piler storage were good while some to the Shovel pile were good and some frosted. There was intermittent rain and snow after the middle of October for the balance of the harvest period. Temperatures after November 15th were generally low, freezing the beets badly, this continuing up to the close of slicing in January.

Average time samples were in storage was 51 days with a sugar loss of .66 lb. per day.

Factory 6. The beet samples went into the Piler storage in good condition. Coming out of storage most were good with the balance showing some rot and mold and partly soft. The sugar loss per ton per day was .42 lbs., with average time in storage of 26 days.

Samples for the first year series average 16.40 percent Sugar and 85.3 Purity. For the series of the second year the sugar content is 16.25 with 85.3 Purity; therefore the beets for the two year's series are almost identical.

There are several important points which, if adherred to, should aid materially in reducing sugar losses.

1. Frosted or diseased beets should be kept out of storage piles.
2. Only clean, trash-free and mature beets should be stored.
3. Reduce the time in storage to the minimum.
4. Development of some means of lowering temperature of beets in piles that will be practical from the standpoint of large scale operation.

A tabulation of average results for each factory, as well as the averages for each series is incorporated in this paper.

SUGAR LOSSES IN BEETS IN STORAGE

	FACTORY										
	1	2	3	4	5	6	1932 GEOM. AVGS.	1	2	3	1936 GEOM. AVGS.
Number of samples	7	15	10	24	17	16	89	10	8	7	25
Avg. No. of Days in Pile	41.5	37.7	25.0	38.0	51.0	25.9	36.5	29	46	43	39
Beets, % Moisture											
Into Pile	76.26	77.46	80.16	78.02	76.03	75.12	77.15	75.36	77.70	77.95	76.59
Out of Pile	74.79	77.24	79.15	76.74	76.69	75.25	76.83	74.38	77.00	77.94	75.93
Difference	-1.47	-.22	-1.01	-1.28	+.66	+.13	-.32	-.98	-.70	-.01	-.66
Beets, % Sugar											
Into Pile	17.52	16.77	14.14	15.40	17.38	17.40	16.40	16.95	15.45	15.86	16.25
Out of Pile	18.39	16.28	14.99	16.25	16.76	17.23	16.55	16.85	15.52	15.29	16.11
Difference	.87	-.49	.85	.85	-.62	-.17	+.15	-.10	+.07	-.57	-.14
Beets, Purity											
Into Pile	87.3	86.1	82.6	83.9	86.3	85.3	85.3	86.4	84.3	84.4	85.3
Out of Pile	86.5	83.8	82.5	82.9	85.2	85.2	84.4	85.6	82.8	82.4	84.1
Difference	-0.8	-2.3	-0.1	-1.0	-1.1	-0.1	-0.9	-0.8	-1.5	-2.0	-1.2
Moisture Loss, % on Beets	7.11	5.10	7.04	7.90	3.56	1.27	5.17	5.37	3.87	3.80	4.58
Sugar Loss, % on Sugar	2.95	8.60	2.09	3.59	9.64	3.16	5.46	6.53	3.68	8.27	5.96
Sugar Loss, % on Beets	.52	1.44	.30	.55	1.68	.55	.90	1.10	.57	1.31	.97
% Weight Shrink	7.54	6.29	7.63	8.63	6.27	1.86	6.31	5.97	4.11	4.86	5.15
Moisture + Sugar Loss, % on Beets	7.63	6.54	7.34	8.45	5.24	1.82	6.07	6.47	4.44	5.11	5.55
Lbs. Sugar Lost per ton Beets per Storage Day	.25	.76	.24	.29	.66	.42	.49	.76	.25	.61	.50

All moisture, sugar, and purity determinations in duplicate.

A PRELIMINARY REPORT OF PETIOLE ANALYSIS AS AN INDICATION OF THE FERTILIZER REQUIREMENTS OF SUGAR BEETS

C. R. Koontz and Geo. Goldfain

At the time we were asked to prepare this paper we were pleased to be afforded this opportunity, and had outlined a number of experiments that would have made this paper more worthwhile. Due to a transfer of one of the authors to another locality during the summer, some of the experimental plots were lost and the final objectives lost or incompleted. We, therefore, wish to offer this paper only as a preliminary report in the hope that it may stimulate further experimentation by more sugar chemists.

One of us once worked with a very estimable chemist who formerly taught Chemistry in one of the better Colorado Universities, and one of his statements regarding chemists was as follows: "There are research chemists, chemists, sugar chemists and morons". We will classify ourselves somewhere in the substrata below the sugar chemist level. We have written this paper with the hope that it may benefit the average factory chemist equipped with average laboratory equipment.

During the early stages of evolution of soil sciences chemical analyses of soils furnished the chief means of soil diagnosis and the more three general systems of soil analysis practiced for a long time were total soil analysis, analysis of soil portions soluble in strong acids and analyses of dilute acid or water extracts of soils. These results were used in varying degrees to interpret the quality of soils with respect to their content of nutrients either harmful or beneficial to various types of crops.

The first two methods have given valuable information concerning chemical compositions of soils but also determine constituents not immediately soluble in soil solutions for ordinary cropping conditions. These results are therefore of little value for purposes of correlating the fertilizer requirements of soils with the analyses.

The third method named has been the most popular in latter years chiefly because of the part played by the soil solution and the easily soluble soil contents in maintaining plant growth particularly during its critical periods.

In the everlasting search for more suitable methods the Winogradsky biological method was next developed and has been commonly called the spontaneous culture method. After numerous tests and applications under practical conditions the value of this method seems to be quite limited and has been relegated to the background.

Following this, methods were developed wherein buffered solutions were used for extracting the soil. The results obtained by such methods indicated more accurately the elements available for plant growth. Various types of buffered solutions have been used and analytical methods have been developed by such eminent men as Morgan, Carolus, Thornton and Brown whose phosphate method is now used exclusively by The Great Western Sugar Company.

The aforementioned researchers then realized the possibilities and value of petiole analyses as indications of soil fertility requirements. Messrs. Gardner and Robertson were among the first to work on petioles grown on western soils.

Encouraged by the splendid results of these experiments we decided to follow up the study as it applied to our own locality. We make no claim to originality as most of our methods used are adapted with slight modifications from the methods set forth by these earlier men. Much of the past work has been carried out on plants other than sugar beets and we feel that this type of work may well be conducted by the factory chemist for the sugar beet industry.

The factory chemist is on the ground throughout the growing season and has opportunity to observe all types of cultural practices on good and poor types of farms. He also has the opportunity of sampling petioles under varying conditions of drought, moisture, hail and insect injuries as well as bacterial and virus diseases.

We know by actual observation that metabolism is affected by these conditions and that petiole analysis under such conditions is not a true measure of fertilizer requirements. Under true research conditions these adverse factors could be carefully controlled but in the practical state these factors must be considered and readily recognized in order to correlate petiole analysis with soil needs.

These studies can best be made in the field and for this reason the problem is well adapted as research for the factory chemist.

Our work on petioles was first conducted in the Lyman, Nebraska area. In this work we have assumed that healthy plants making vigorous growth on favorable soil will select the plant nutrients in concentrations most favorable to their needs. Most of the analyses reported in this paper are based on such comparisons and in our early work no attempt was made to evaluate the nutrients in terms of parts per million of plant tissue. We evaluated them in a manner similar to that used by earlier workers, i. e., comparative terms of low, medium, and high.

We tried a series of pot tests on a soil known to be deficient in phosphate and on which blackheart had definitely developed during the previous year. Seven groups of pots were set up as follows:

Group No.	Number of Pots	Treatment
1	5	100# Superphosphate per acre
2	5	200# " " "
3	5	400# " " "
4	5	200# " " "
		200# Sodium nitrate " "
5	5	200# Superphosphate " "
		6 Tons Calcium Carbonate " "
6	5	200# Sodium nitrate " "
7	20	No treatment

Seed planted on March 6th began to sprout on March 14th but due to poor conditions of temperature and light growth was slow. It was not until May 28th that the plants were large enough to sample. This first group of pot samples are referred to the color charts in the bulletin by M. F. Morgan- Number 372- "The Universal Soil Testing System"- Connecticut Agricultural Experiment Station. The terms High, Medium and Low should not be confused with the terms High, Normal and Low used in describing the field samples taken later. Even at their best the potted plants never contained the high concentrations of the field plants. At the beginning of the experiments phosphorus was the only element determined.

On May 28th all groups were tested and all were about alike giving what we would call a medium high by the color chart. One week later all pots were again tested. Groups 1, 2, 3, 4 and 5 still gave a medium high phosphorus test. Groups 6 and 7 gave medium tests. On June 12th groups 1, 2, 3, 4, and 5 still gave medium high tests. Groups 6 and 7 had dropped to low. On June 20th groups 1, 2, 3, 4, and 5 remained medium high. Group 3 containing 400# superphosphate per acre contained no more than group 1 containing 100# of superphosphate per acre. Groups 6 and 7 had dropped to very low and contained scarcely enough phosphorus to give the test. Ten individual plants from group 7 showed little variation.

By this time the potted plants were sickly in appearance and growth had almost stopped. This was true of all groups, the untreated plants appearing as good as the treated ones. The plants in the field had far outgrown them. It was decided to abandon the experiment on pots and work on plants from the fields.

As early as June 5th we obtained plants from the fields. We selected virogous and healthy plants growing on soils that have produced good tonnage and high sugar. When we compared our tests of these with the color charts we had quite a different picture. We give here an average of several comparisons.

Nitrate Nitrogen	Very High
Phosphorus	High
Potassium	Extra High
Calcium	High
Magnesium	Medium
Aluminum	Low
Iron	Medium

These high concentrations exist in the young healthy beet, but as they increase in size and the season advances the concentration diminishes. From this point on analysis will be reported as Normal, High and Low. Normal meaning the concentrations in normal beets growing on good soils. High and Low meaning very definite differences. No attempt is made to draw fine distinctions. Many individual samples from the same soil were tested growing side by side. Then, as now, we are not concerned as to whether the petiole contains 3 or 5 parts of phosphorus per million, but whether it contains 5 or 40 ppm.

The remainder of the work consisted of testing field samples. In selecting these samples we looked for evidence of abnormal growth and in particular, fields showing evidence of blackheart. Some examples of the general results are given here.

June 29th.

Beets growing on the Meyer farm showed a slackening of growth and were not as large as average beets. They needed irrigation. The analysis of the petioles was as follows:

Nitrate Nitrogen	Very High - 4 to 5 times normal
Phosphorus	Twice as high as normal
Magnesium	Twice normal
Potassium	Thrice normal
Iron	Low

The analysis of the soil on which the beets were growing, in terms of Morgan's standards, was as follows:

Nitrate Nitrogen	70# per acre
Phosphorus	300# " "
Potassium	600# " "
Magnesium	50# " "
Iron	15# " "

At harvest time this field yielded 12.85 tons per acre with 15.8% sugar content.

July 1st

Samples taken from Foster field. These beets needed water and growth had been slight for the past ten days. Analysis of petioles is as follows:

Nitrate Nitrogen	3 to 4 times normal
Phosphorus	2 times normal
Potassium	4 times normal
Magnesium	Normal
Iron	Low

Soil from the Foster farm:

Nitrate Nitrogen	40# per acre
Phosphorus	100# " "
Potassium	800# " "
Magnesium	25# " "
Iron	15# " "

The final yield on this field was 8.53 tons per acre with 17.4 sugar content.

August 10th

A field on the Stricker farm developed what we believed to be black-heart. A large percent of the beets were affected. Apparently healthy beets were growing within two or three feet of the affected beets. The field had had a light irrigation the previous week. Samples were taken from the healthy beets and the affected ones. Analysis is as follows:

	Healthy Beets	Affected Beets
Nitrate Nitrogen	Normal	High
Phosphorus	High	Low
Magnesium	Normal	Normal
Potassium	High	High
Iron	Highest found in all tests	Low

August 12th

A field on the Walter Butcher farm had shown good growth up till August 1st. A condition resembling blackheart had developed through the field with the exception of an area on which a straw pile had burned or rotted. The beets in this area were very fine and growing well. Samples taken from both areas compared as follows:

	Beets on strawstack area	Rest of field
Nitrate Nitrogen	Normal	High
Phosphorus	High	Low
Magnesium	Normal	Normal
Potassium	High	High
Iron	High	Low

August 15th

A sample from the Shultz farm. These beets were slowing down in growth, and had been watered the week before. A large percent of the beets around the edges of the field had developed a yellowing of the leaves. This was not the characteristic yellow due to the loss of nitrogen but a more intense color, it being about half the shade of a lemon peel. In some cases there were yellow and green leaves on the same plant. Tests from the green and yellow petioles from the same plant gave the same analysis. Healthy beets were selected growing near the affected beets. The analysis was as follows:

	Healthy Beet	Yellow Leaved Beet
Nitrate Nitrogen	Normal	Normal
Phosphorus	Normal	Low
Magnesium	Normal	Normal
Iron	Trace	None
Potassium	High	Highest in any test

August 24th

A field of beets on the J. K. Butcher farm developed spots of blackheart. Samples were taken from the affected beets and about five feet away samples were taken from healthy beets. These tested as follows:

	Unaffected Beets	Affected Beets
Nitrate Nitrogen	High	Slightly below Normal
Phosphorus	Low	Very Low
Potassium	Normal	Normal
Magnesium	Normal	Low
Iron	Low	Trace

Further study and more information from other authors previously mentioned in this paper influenced us to change our original technique. Later experience has taught us that while the dyphenylanine tests for nitrates gave good results in Mr. Morgan's hands we were unable to obtain consistent results with it.

The changed technique also led to a discovery which we believe to be of importance. We were working on petioles which gave low phosphate tests. The procedure for this analysis at that time was to grind two grams of petioles with approximately .25 grams of Darco and 10 ml of a 2% acetic acid solution. This was filtered and 5 ml were mixed with 5 ml of Brown's reagent, Truog indicator added for color development and comparisons made after ten minutes. The solutions given by these petioles showed a greenish cast which interferod with final color comparisons. In the effort to overcome this we tried charring two grams of petioles in a platinum dish over a flame at a dull red heat. On taking up this charred residue with the two percent acetic acid solution and filtering, we obtained a clear solution and much to our surprise obtained a higher phosphorus test. We repeated the experiment with like results.

After this discovery we made it a point to ash all petiole samples found low in phosphorus and obtained a much higher reading. This led us to believe that some of the phosphorus was in an organic form. We tried ashing petioles with magnesium nitrate and taking up both with acetic and hydrochloric acid. We did not obtain higher phosphorus tests on these samples than we did on the charred samples. From then on we made it a practice to char all petiole samples. This gave us much more consistent results.

We found that charring petioles giving a high phosphorus by the old method did not increase the test materially, but in low phosphorus tests charring materially increased it.

We are not prepared to say definitely what function the organic phosphorus plays in plant metabolism. We do know however that beets beginning to be affected with blackheart show a rapid decrease in both organic and inorganic phosphorus. We observed one case wherein beets growing on soil which had previously given a doubtful phosphorus soil test began to develop typical blackheart. Beets across the road on good soil gave a total phosphorus content of approximately 60 ppm. The beets beginning to show blackheart contained approximately 12 ppm. total phosphorus. Test rows of these beets were treated with superphosphate in the equivalent of 600# per acre. In spite of the fact this was late in July these test rows had remarkable recovery and within two weeks contained more total phosphorus than the healthy beets to which they were compared. At harvest time these test rows yielded about 8 or 9 tons per acre, while the remainder of the field was practically a total loss. Most of our district soils have been so well phosphated in past years that few fields can be found showing blackheart.

This affords little opportunity for determining the extreme phosphorus deficiency at which blackheart will probably occur.

As regards other necessary elements for plant growth, such as potassium and calcium, we found these present in large quantities in the petioles in all beets grown in our territory. This would indicate that our soils have a large sufficiency of these elements, and even though the beet has an enormous appetite for these salts, we felt it was not necessary to make analyses for these salts a routine procedure, as it will be a long time before addition of

such salts to the soil may be necessary.

Other lesser elements of plant growth, such as magnesium, manganese, and iron, were always found to be present in slight traces, but distinctions as to the amount could not be made between good and poor beets. It was therefore decided to abandon these as routine tests.

The sugar beet seems to be able to select the optimum amount of phosphorus necessary for vigorous growth, petioles of beets growing on soil containing 200# of phosphorus per acre showing almost the same amount of phosphorus as petioles of beets growing on soil containing 1000# of phosphorus per acre.

This, however is not true of nitrates, for beets will absorb nitrates in proportion to the concentration of nitrates in the soil. High nitrogen in the petiole is therefore direct evidence of high nitrogen in the soil with the exception of cases of beets suffering injury or drouth, wherein the nitrates may increase to large proportions, even on soils of low nitrate content. As evidence of this a field sampled early in June was injured by hail. Three days later the nitrogen content had increased about four times.

As this is a preliminary report it might be well to state our tentative plans for future work wherein periodic analyses will be made on selected fields of both good and poor beets. The petioles will be analyzed for phosphorus and nitrates with occasional analyses for some of the less important elements.

After trying various methods we have adopted the two following methods for the determination of phosphorus and nitrates viz. Thornton's method for phosphorus with slight modifications, and the phenol-disulphonic acid method for the nitrate test:

Sampling. Petioles are selected from several plants at random over the field. These are cut in pieces about 2 mm. thick and mixed.

Method. Two grams of the sample are weighed out and ground with, .25 grams of Darco (phosphate free) and 10 ml of Thornton's phosphorus reagent. This is then filtered through a 12.5 cm. Whatman paper No. 5. The filtrate is placed in a test tube. A small amount of stannous oxalate or La Motte Turog reducer is added. (The amount that can be picked up on the end of a toothpick is enough.) The color is allowed to develop for five minutes and the solution is compared with standards. (Actual standards can be matched with a solution of night blue and alcohol.)

In addition to this 2 grams of petioles are carbonized at a dull red heat, after cooling 10 ml of Thornton's phosphate reagent are added. The carbonized petioles are broken up with a glass stirring rod and the mixture filtered. The procedure is then the same as before.

Thornton's Phosphate Reagent: The test solution is prepared by dissolving 4 grams of ammonium molybdate in 500 cc. of distilled water and adding to it slowly and with constant stirring a mixture of 437 cc. of distilled water and 63 cc. of concentrated hydrochloric acid. This gives an acid concentration of approximately 0.75N. Where large quantities of the reagent are to be used it may be more conveniently made up in more concentrated stock solutions and diluted with distilled water as needed. The more concentrated solu-

tions will keep indefinitely if properly stored while the dilute solution, as prepared for the test, often develops an appreciable blue color on standing for several weeks. Storage of Pyrex bottles in a cool place will prevent such deterioration, to a large extent.

Nitrate Nitrogen.

Sampling. Take 2 gms. of finely cut petiole tissue and place in a small 50 c.c. mortar containing 10 ml of 2% acetic acid and .25 gms. of phosphorus free Darco. Grind the mixture intermittently for 10 minutes and then filter through a 12.5 cm. Whatman No. 5 filter paper. The filtrate is now ready to use in determining nitrogen. One gram of plant tissue is represented by 5 c.c. of the filtrate.

Method. With phenol-di-sulphonic acid.

Evaporate to dryness 1 - 2 c.c. of the filtrate, to which has been added .5 - 1 c.c. of 10% NaOH, in a pyrex beaker over a water bath or an alcohol lamp. Dissolve the salts with 2 c.c. of phenoldisulphonic acid and allow to stand 5 minutes. (Phenoldisulphonic acid is prepared by dissolving 25 gm. of pure phenol in 150 c.c. of concentrated H_2SO_4. Add 75 c.c. of fuming sulfuric acid and heat in a boiling water bath for two hours.) Add water and 30% NaOH until the yellow color has developed to its maximum intensity. Make to 50 or 100 c.c. depending on density of color and compare with a standard in a colorimeter.

A standard solution containing 100 ppm. of NO_3-N results when .722 gms. of KNO_3 are dissolved in a liter of water. One-half, 1, 1½ and 2 c.c. of this solution equals a comparative concentration of 250, 500, 750, 1000 p.p.m. in the plant when 1 c.c. of the filtrate is used and both solutions are made to the same volume.

Summary and Conclusions

1. Preliminary tests indicate that the petiole analysis is a better index to soil requirements than soil analyses especially in beets grown on Western soil.

2. The methods are simple and can be worked in any factory laboratory.

3. The factory chemist is on the ground and has ample material and conditions of growth on which to experiment.

4. Analyses of petioles under adverse growing conditions or injury may not be indicative of the soil fertility.

5. Phosphate determination should be made on green petioles and the carbonized petioles. They should be studied in conjunction with each other.

We close with an apology for the meagre data we are able to supply, but if we have encouraged anyone to take up this work we feel that it will eventually result in benefit to the industry.

COMPOSITION OF THE SOLUBLE NON-SUGARS IN BEETS AND THEIR ELIMINATION DURING PROCESSING

By A. R. Nees

Every step in the sugar refining process is directly concerned with, or is incidental to the separation of sugar from the accompanying non-sugars.

In the processing of beets there are two steps which are chiefly concerned with the elimination of non-sugars, - the diffusion battery and first carbonation. Average beets contain about 135 to 140 pounds non-sugar, other than water, per ton. Aproximately 90 to 100 pounds of insoluble matter in form of pulp is removed in the battery and 35 to 40 pounds is carried into the raw juice. The carbonation process removes 12 to 15 pounds. The remainder goes on into the sugar end and eventually passes out with the molasses.

Every sugar technologist since the beginning of the industry, has given attention to both the diffusion and carbonation operations, with a view to increasing the elimination of non-sugars, thus increasing the yield of granulated sugar and decreasing the quantity of molasses.

The chief function of the battery is to separate soluble constituents of the beets from the insoluble.

Some believe that osmosis or "selective diffusion" take place in the battery and that it may be so operated as to improve the purity of the diffusion juice. It is probably true that certain colloidal cellular matter is coagulated by heat and mechanically filtered out in the battery. Beyond this there is not much evidence that soluble non-sugar is removed. On the other hand there is much evidence that, under conditions of high temperature and a long time of retention, hydrolysis or dissolution of certain constituents such as hemi-celluloses and pectin-like compounds occur, thus causing a lowering of purity. The elimination of impurities in the battery is only of importance if something is removed which cannot be removed by lime and carbonation.

So far as the removal of colloidal and soluble non-sugars is concerned the standard practice is, of course, the treatment with milk of lime or calcium saccharate and subsequent removal by carbonation and filtration. Many methods have been proposed to supplant or supplement the lime treatment, but none have proven feasible from an economic standpoint. Many variations in technic have been adopted from time to time with the idea of improving the precipitation and removal of impurities. Their value is uncertain. At times good results are obtained with little effort - at other times poor results are obtained in spite of all one can do.

It was this uncertainty which prompted the inception of the work reported in this paper. It was often noticed that beets from adjoining territories gave different results in the respective factories in which they were processed. This was particularly noticeable in two Colorado districts. The factories are of comparable size, have similar equipment and maintain, as far as possible, the same operating conditions. Yet one with poorer quality beets invariably obtained a higher elimination of non-sugars as measured by the purity of thin juice and molasses production. The average figures for the five-year period immediately preceding the tests are shown in Table I.

TABLE I

	Sugar Percentage on Beets	Apparent Purity Beets	Apparent Purity Thin Juice	Sugar in Molasses Percentage on Beets
District No. 1	15.30	83.9	88.8	1.99
District No. 2	15.80	85.4	88.8	2.08

Table II shows similar figures for the year in which the tests were made.

TABLE II

	Sugar Percentage on Beets	Apparent Purity Beets	Apparent Purity Thin Juice	Sugar in Molasses Percentage on Beets
District No. 1	14.61	84.6	89.0	2.24
District No. 2	14.61	84.7	87.7	2.27

The difference in the results obtained by the two factories is obvious and this investigation was undertaken to determine the reason for the difference.

The tests were carried out in accordance with the following procedure: Apparent purities (refractometer dry substance and direct polarization) were run on daily composite samples of pressed juice, diffusion juice and thin juice (second saturation juice) and on colloid-free pressed and diffusion juice. All daily samples were concentrated and composited by weeks for more complete analysis. Corresponding composite samples of molasses were also obtained. Analyses were made on all weekly samples for total nitrogen, proteins, non-protein nitrogen, nitrate nitrogen and lixiviated ash.

Non-protein nitrogen compounds were calculated from the non-protein nitrogen by multiplying by the factor 9.0. The non-nitrogenous organic compounds were determined by difference. This is admittedly an empirical method but it is believed to permit a fair comparison of the composition of the various juices.

Finally all results were reduced to campaign averages. It is these latter figures which will be discussed.

The various non-sugars are shown in Chart I and Table III, expressed as pounds per ton of beets. This method of expression makes it possible to compare not only the different juices from the same district, but to compare those of the two districts, since the beets have the same average sugar content.

First, compare the composition of pressed juice from the two districts. The total non-sugars in No. 1 is 43.4 lbs. per ton of beets and in No. 2, 43.7, practically the same. The inorganic compounds are also the same, being 13.5 pounds per ton of beets. There is a decided difference in nitrogenous compounds. Proteins, non-protein nitrogen compounds and nitrates are all higher in the beets from District No. 2, by 1.2, 1.3 and 0.5 pounds respectively. The non-nitrogenous organic compounds are lower by 2.9 pounds.

Comparison of the non-sugars in pressed juice and diffusion juice is of interest from the standpoint of so-called "battery elimination".

There is a reduction in the total non-sugar in diffusion juice as compared to pressed juice of 8.6 pounds per ton in No. 1 beets and 4.6 lbs. in No. 2 beets. The difference is largely accounted for by an increase in ash and only a slight decrease in non-nitrogenous organic in No. 2 beets, while there is a decrease in ash and a relatively large decrease in non-nitrogenous organic compounds in No. 1. The increase in ash in No. 2 beets is partly due to solids in the battery supply water and the addition of soda ash to the battery, 0.55 pound and 0.22 pound per ton of beets coming from these respective sources.

(Battery supply water for No. 1 factory had the equivalent of 0.06 pound solids per ton of beets and no soda was added to the battery.)

After making these corrections, No. 1 beets still show 0.52 pound per ton greater reduction in ash than No. 2. Apparently there is an elimination of substantially more ash constituents from No. 1 beets in the battery. This point will be discussed later.

The comparison of diffusion juice with thin juice shows the effect of liming and carbonation on the removal of non-sugars. The most obvious thing is that the thin juice from No. 2 beets contains 3.1 pounds more non-sugar than No. 1. When the proper corrections are made for solids in battery supply water and soda ash used in process in both factories, the difference is reduced to 2.4 pounds. This amount of non-sugar will carry 3.6 lbs. of sugar into the molasses at 60 purity or increase the sugar in molasses 0.18% on beets. The reason for this difference in elimination lies in the fact that No. 1 beets contain a relatively large amount of non-nitrogenous compounds which are readily eliminated, while No. 2 beets contain a large amount of nitrogenous compounds which are not eliminated. This results in the production of lower purity thin juice and consequently a higher molasses production from No. 2 beets. The elimination of other types of non-sugar is practically the same for both districts.

Colloid-free pressed and diffusion juices were prepared by treating with colloidal aluminum hydroxide. The alumina hydrosol carries a positive electric charge while the juice colloids are negatively charged. A mutual precipitation occurs when the two types of colloids are brought together. Chart I and Table III show the amount of each type of non-sugar precipitated by alumina hydrosol. The remainder is assumed to be in true solution.

Practically all of the proteins are removed but only a small part of the non-protein nitrogen compounds. Beets No. 1 show 50% greater ash removal in colloidal form than No. 2. Again the most marked difference is in the non-nitrogenous organic compounds. Forty per cent of these compounds are precipitated from the pressed juice of No. 2 beets and 36% from that of No. 1 beets, while only 16% are precipitated from the diffusion juice of No. 2 and 23% from No. 1. It is to be noted too that there is more of these compounds in the colloid-free diffusion juice than in the pressed juice of No. 2 beets, while the reverse is true for No. 1 beets. It is indicated that some of these compounds in No. 2 beets are changed from the colloidal to the true solution state in the battery. Apparently, however, they are removed by lime so that the net effect of this conversion on the purity of thin juice is negligible.

The composition of non-sugar in molasses is the same as that of thin juice, with the exception of the non-nitrogenous organic, which shows an increase of 2.2 pounds per ton of beets for District No. 1 and 2.3 pounds for No. 2. This increase is the result of the inversion of sugar during the process and is made up of invert sugar and its decomposition products.

Table IV shows the composition of the inorganic compounds. As pointed out before, total inorganic compounds, expressed as lixiviated ash, is the same in the pressed juice from the beets of both districts, and there is less ash elimination from No. 2 beets even after a correction is made for solids in battery supply water and soda ash. The reason becomes apparent when it is noted that there is an increase in alkali compounds from pressed juice to diffusion juice which, of course, carries through to thin juice. These additional potassium and sodium compounds evidently come from the hydrolysis of alkali-organic compounds in the battery. Whether this hydrolysis is influenced by the method of battery operation or is an inherent characteristic of the beets is not known. It is known, of course, that calcium, magnesium and phosphorus compounds are removed at carbonation. This is clearly indicated by the figures in the table. Practically none of the chlorides are eliminated. Forty-seven per cent of the sulfates are eliminated from No. 1 beets while there is an increase of 25% in the thin juice from No. 2 beets. This latter figure is obscured by an unknown addition from battery supply water.

The association of the inorganic substance in the colloidal phase shows some interesting variations. For example, in No. 1 beets both sodium and potassium are removed with the colloids. In No. 2 beets neither of these is removed, but instead an equivalent amount of magnesium is precipitated. Practically all of the calcium, silica, iron and alumina, and about one-half the phosphorus are shown to exist in colloidal condition.

If one were able to resolve the organic substance into their component parts as easily as the inorganic, a more complete picture would be obtained and the problem of elimination could be attacked in a more intelligent manner. It is apparent that 80% to 85% of the non-sugars in thin juice are composed of two groups, inorganic and non-protein nitrogenous compounds. It is evident, therefore, that any improved method of juice purification will be successful only in proportion to its ability to remove those substances. Such a method will have to be a radical departure from the present one, probably a supplemental method which will follow the lime and carbonation process. The development of such a method is not impossible from a technical standpoint. The economic factors will govern its application.

This discussion has pointed the difference in the relative proportion of the various non-sugar in beets which have the same sugar content and purity. This difference is undoubtedly a function of soil fertility, agricultural methods and climatic conditions. The contention of many operating men that factory results are influenced by the quality of beets is borne out by these results, although it is doubtful if all operating troubles can be ascribed to this source.

Acknowledgment

The writer wishes to acknowledge the valuable assistance of Messrs. R. J. Brown, A. N. Bennett, E. H. Hungerford and others who carried out the prodigious amount of analytical work involved in this investigation.

TABLE III

POUNDS NON-SUGARS PER TON BEETS

	Protein Compounds	Non-Protein Nitrogen Compounds	Nitrates N_2O_5	Ammonia NH_3	Inorganic	Non-Nitrogenous Organic Compounds	Total	Purity
DISTRICT NO. 1								
Pressed Juice	3.42	9.05	0.82	0.17	13.51	16.45	43.43	*86.05
Colloid-free Pressed Juice	0.30	8.20	0.88	0.15	12.15	10.54	33.25	88.97
Diffusion Juice	1.22	8.00	0.74	0.15	12.97	11.78	34.80	88.63
Colloid-free Diffusion Juice	0.38	7.93	0.77	0.16	12.25	8.91	30.61	89.63
Thin Juice (2nd Saturation)	0.00	7.50	0.77	0.03	11.75	3.84	23.74	91.98
Molasses	0.00	7.50	0.77	0.03	11.70	6.10	26.20	**61.63
DISTRICT NO. 2								
Pressed Juice	4.63	10.31	1.34	0.26	13.55	13.56	43.65	*85.98
Colloid-free Pressed Juice	0.04	9.84	1.26	.25	12.49	8.30	32.17	89.00
Diffusion Juice	1.66	9.91	1.15	.25	12.97	12.07	39.11	87.43
Colloid-free Diffusion Juice	0.12	9.54	1.20	0.24	13.52	10.17	34.80	88.63
Thin Juice (2nd Saturation)	0.19	8.99	1.27	0.04	12.79	3.48	26.76	90.95
Molasses	0.04	9.07	1.21	0.03	12.70	5.80	28.80	**60.89

*Purity by refractometer dry substance and direct polarization.

**True purity, double enzyme method.

TABLE IV

ASH CONSTITUENTS
POUNDS PER TON OF BEETS

	Pressed Juice	Colloid-free Pressed Juice	Diffusion Juice	Colloid-free Diffusion Juice	Thin Juice	Molasses
			DISTRICT NO. 1			
SiO_2	0.09	0.02	0.03	0.01	0.02	0.02
R_2O_3	0.19	0.06	0.06	0.09	0.01	0.05
CaO	0.40	0.06	0.15	0.06	0.05	0.12
MgO	1.04	1.00	1.03	0.86	0.02	0.01
K_2O	5.03	4.86	5.14	5.04	5.21	5.19
Na_2O	1.93	1.84	1.92	1.87	2.07	2.11
Cl	1.62	1.67	1.46	1.58	1.55	1.60
SO_3	0.69	0.61	0.43	0.43	0.34	1.64
P_2O_5	0.69	0.32	0.53	0.35	0.04	0.03
CO_2 (Calc'd)	2.26	2.11	2.43	2.32	2.74	2.14
			DISTRICT NO. 2			
SiO_2	0.09	0.02	0.05	0.03	0.02	0.02
R_2O_3	0.20	0.08	0.11	0.11	0.00	0.02
CaO	0.28	0.04	0.11	0.04	0.07	0.08
MgO	1.04	0.84	0.93	0.67	0.02	0.02
K_2O	5.10	5.09	5.56	5.55	5.49	5.55
Na_2O	2.03	2.01	2.20	2.25	2.40	2.40
Cl	1.20	1.34	1.18	1.31	1.19	1.28
SO_3	0.46	0.50	0.75	0.69	0.58	1.73
P_2O_5	0.77	0.31	0.64	0.34	0.40	0.03
CO_2 (Calc'd)	2.66	2.57	2.82	2.85	3.25	2.57

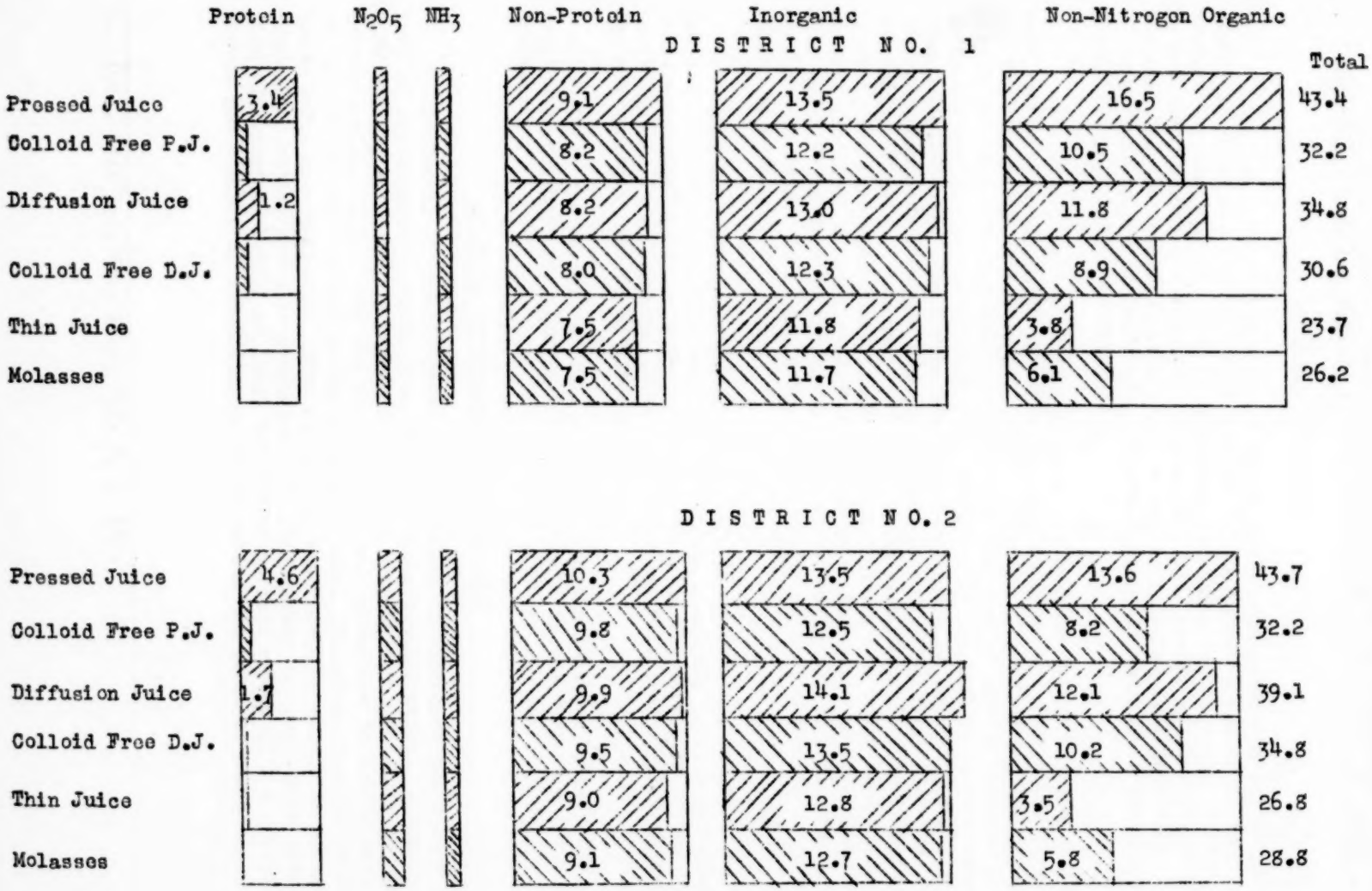

Chart No. 1

Pounds Non-Sugars per Ton of Beets

RELATION BETWEEN PLANT AVAILABLE PHOSPHATE AND PHOSPHATE EXTRACTED BY SODIUM ACETATE BUFFER IN IRRIGATED ROCKY MOUNTAIN SOILS

Robert J. Brown

The improved sodium acetate buffer method for determination of plant available phosphate was published in 1937.[1] The method makes no attempt to measure the absolute quantity of available phosphate in the soil. Rather, it is designed to show the relation between the total easily soluble phosphate in the soil and the readiness with which it may be released from the soil. Both of these factors are of importance in determining the ability of the plant to obtain its phosphate requirements.

The concentration of phosphate in the acetate buffer extract of the soil varies with the ratio of buffer to soil employed and very often it does not vary inversely with this ratio over the range of extraction rations generally used. And all soil samples which have been tested show a decrease in phosphate content of the extract if a sufficiently low buffer to soil extraction ratio is used. The forces tending to release phosphate into solution become weak compared to those tending to keep it out of solution when the concentration of soil in the mixture becomes high enough. This same phenomenon is exhibited when water only is used for extraction. In order to gain an idea of both the level of easily soluble phosphate in the soil, and the tenacity with which it is held by the soil, the acetate buffer method employs extraction of the soil at two buffer to soil ratios, namely, 5 to 1 and 20 to 1 parts buffer to soil.

Empirical standards for grading soils as sufficient, doubtful and deficient in phosphate have been set up. These standards provide satisfactory measurement for the large majority of the soils in the territory served by The Great Western Sugar Company. Many soils from the Salt River Valley in Arizona are not correctly graded by these standards.

It is the purpose of this paper to show the relation between the extractable phosphate and plant available phosphate in the various soils encountered.

ANALYSES OF REPRESENTATIVE SAMPLES

Tables I, II and III present the results of phosphate tests on a variety of representative soils from the area under consideration. These samples have been selected from a large number which have been subjected to special investigation. They cover the range from excess phosphate to severe deficiency. On many of the soils field trials have been made. On others results of Neubauer tests are available. Some figures on water soluble phosphate at various extraction ratios are also presented. On all samples the results of extraction with acetate buffer at least two buffer to soil ratios (5/1 and 20/1) are shown, and results of extraction at other ratios are shown on many.

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1. Proc. Soil Sci. Soc. Amer. Vol. 2, p. 185.

The group of eight samples in Table I includes the common loam and sandy loam soils of northern Colorado and western Nebraska. The phosphate content of the acetate buffer extract obtained at the 5/1 buffer to soil ratio is invariably greater than that of the 20/1 ratio extract, but except in abnormally high phosphate soils the phosphate content of the 5/1 extract is not twice as high as the phosphate content of the 20/1 ratio extract. The first in the list is a very fertile soil. The second is also a high yield soil and shows a sufficiency by all methods used (acetate buffer, Winogradsky, Neubauer and K_2CO_3 solution). However, the excess of phosphate is not great and fertility is maintained by regular use of manure and treble superphosphate. Next in the list are two samples in the doubtful range. In field trials one of these indicated no deficiency and the other gave a very slight, though not statistically significant, response. Two of the last three samples were shown to be definitely deficient by field trials. The last in the list is a poor, severely deficient soil.

On soils of this type the correlation between phosphate content of the acetate buffer extract and plant available phosphate is simple. And the result of extraction at single buffer to soil ratio could be employed to classify the soil as to available phosphate grade.

The second group of eight soils in Table II is representative of the Wyoming area. Soils showing similar reactions are found in extreme western Nebraska and in the deficient clay and heavy clay loam soils in Colorado.

Only when the soil is very high in phosphate does the 5/1 ratio buffer extract contain a decidedly higher concentration of phosphate than does the 20/1 ratio extract, and generally the 5/1 ratio extract is definitely the lower in phosphate concentration. All the soils listed show rather high phosphate concentrations in the buffer extracts. Soils yielding extracts with much lower phosphate concentrations are common, but they are very deficient and a discussion of them is unnecessary. The soils listed in Table II yield extracts, at the 20/1 ratio, high in phosphate. Only the first in the list yields a 5/1 ratio extract of definitely higher phosphate concentration. Fields in this area are generally deficient and this is one of the few which have been built up in fertility sufficiently to give the tests, and also the crop yields, of rich soils. Other fields of the same farm, not so fertile, give tests similar to those on No. 2 of this group. Soils Nos. 2, 3, 4 and 5 all give similar tests by acetate buffer extraction and are listed in order of decreasing Neubauer test. No. 5 was subjected to careful field trials and gave response to phosphate treatment. Samples 6, 7 and 8 yield extracts at 5/1 ratio definitely lower in phosphate than at the 20/1 ratio. Phosphate deficiency is severe as is shown by the Neubauer tests, though good beet yields are obtained on 6 and 7 by phosphating each beet crop.

When the original acetate buffer method was published in 1932,[1] only the results of extraction at 5/1 ratio were used for grading soils. By the standards in use at that time soils such as Nos. 2, 3, 4, 5 and 8 in this group were placed in the doubtful class and those such as Nos. 6 and 7 were placed in the deficient class. Further studies at various extraction ratios and on a wider range of samples brought about a revision of the testing and grading method, as published in 1937.[2]

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1. Jour. Am. Soc. Agr., Vol. 24, No. 6.
2. Proc. Soil Soc. of Amer., Vol. 2, p. 185.

The present grading standards still place soils such as 2, 3, 4 and 5 in the doubtful group. Not all evidence regarding deficiency in these soils is in agreement. Only one field has been subjected to positive field trial. Deficiency was demonstrated. The fields from which these samples were taken are regularly phosphated for beets and the growers are satisfied that the treatment more than repays its cost, though no comparisons of phosphated with non-phosphated areas are made. Neubauer tests show the soils low (from 3 to 5 mg. P_2O_5 per 100 gms. soil) in phosphate, while the soils such as Nos. 6 and 7 are definitely lower, at about 2 or less mg. P_2O_5 per 100 gms. soil. Pot tests on soils such as Nos. 2, 3, 4 and 5 have not demonstrated definite deficiency, while on soils such as Nos. 6 and 7 deficiency is shown with certainty. There is one important reason for giving little weight to the pot test results on these higher testing soils. Extraction at high buffer to soil ratios shows they are very high in easily soluble phosphate. Extraction at the 5/1 ratio shows that much of this phosphate is strongly bound in the soil complex and therefore not available at the high level. In pot tests the dense root system probably greatly increases the CO_2 content of the soil atmosphere above the normal in these soils, of low organic matter content, in the field and the level of available phosphate is probably raised by solution of easily soluble phosphate in the high CO_2 areas in the pots. If we ignore results of pot tests, all evidence points to deficiency in these soils, though not so severe as in soils of the same type but yielding an extract of low phosphate content at the 5/1 buffer to soil ratio.

The soils in Table III are from the Salt River Valley of Arizona. A few soils from other areas in Arizona have given similar results. The level of extractable phosphate is far higher than that in Colorado and Wyoming soils. A few field trials have demonstrated phosphate deficiency and very heavy phosphate applications have become standard practice. Crops are valuable and growers are satisfied with results. We have very little correlation between field trials and acetate buffer tests to guide us in setting standards, but a number of Neubauer tests are available. On the basis of the Neubauer test, the first sample in the list contains a sufficiency of phosphate, Samples Nos. 2 and 3 are questionable, and Nos. 4, 5 and 6 are definitely deficient. The most striking feature of these soils, compared to the Colorado and Wyoming soils, is the wide range of extraction ratios over which the phosphate content of the extract may remain practically constant at a high level, as shown in No. 7 in the list. Even on the very sandy soils, such as No. 5 in the list, the phosphate content of the 5/1 ratio extract is not more than twice that of the 20/1 ratio extract, except in soils of very high phosphate content. There can be no question that there is a different relation between buffer extractable phosphate and available phosphate in Arizona and Colorado soils. A Colorado soil giving the buffer test of Sample No. 5886 would unquestionably be high in plant available phosphate. This sample tests deficient by Neubauer, Windogradsky and Hockensmith* tests. The third sample in the list is still higher in readily soluble phosphate. This sample tests doubtful by Neubauer, Winogradsky and Hockensmith tests. Not many samples have been found giving extracts so high in phosphate and at the same time extracts of lower phosphate concentration at the 5/1 ratio than at the 20/1 ratio, as No. 2 in the list. This sample tests doubtful by Neubauer and indicates a very slight deficiency by winogradsky method.

In general the Arizona soils show much higher level of extractable phosphate than do Colorado and Wyoming soils at the same level of available phos-

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* P_2O_5 soluble in 1% K_2CO_3 solution.

phate. This is true whether distilled water, CO_2 saturated water, acetate buffer or K_2CO_3 solution is used for extraction. A discussion of this subject is not in place here, but McGeorge and Breazeale[1] have offered an explanation.

The eighth sample in the list in Table III is an example of one which shows excessive capacity for maintaining the level of extractable phosphate at high buffer to soil ratios. This soil yields an extract at 50/1 ratio containing a higher phosphate concentration than is yielded at 20/1 or 5/1 ratio. The sample is a severely deficient California soil which has very great capacity for reversion of added phosphate.

EXTRACTABLE PHOSPHATE AND RESPONSE TO PHOSPHATE FERTILIZATION

Empirical standards have been set up for classification of soils as sufficient, doubtful and deficient by the acetate buffer test. These standards are primarily for use by those who are unfamiliar with the known relations between available and extractable phosphate. Under these standards a soil which yields extracts at the 5/1 and 20/1 ratios containing 1.5 and 1.4 p.p.m. of P respectively is graded sufficient, while another soil yielding extracts containing 1.4 and 1.5 p.p.m. of P at the 5/1 and 20/1 ratios respectively is classed as doubtful. Actually there is negligible difference in the available phosphate content of the two soils and response to phosphate fertilization will be controlled by other factors. In setting the grading standards the attempt has been made to be conservative, in order to avoid unnecessary recommendations for phosphate fertilization. However, the evidence now points strongly in the direction of an increase in the limits of the deficient range on those soils in which the phosphate content in the 20/1 ratio extract is practically as great or greater than that in the 5/1 ratio extract.

Considering only the soils of Colorado, Wyoming and western Nebraska, the following grading scheme is highly satisfactory.

Type A Soils - Soils which yield extracts at 5/1 ratio of definitely higher phosphate concentration than is present in the 20/1 ratio extracts.

Deficient soils show 0.5 (or less) p.p.m. of P in the 20/1 ratio extract.

If the 20/1 ratio extract contains between 0.5 and 0.8 p.p.m. of P, the soil is classed as doubtful.

Soils containing sufficient phosphate yield extracts containing 0.8 (or more) p.p.m of P at the 20/1 ratio.

Type B Soils - Soils which yield extracts at the 20/1 ratio containing practically as much or more phosphate than is present in the 5/1 ratio extracts.

Soils which yield extracts at the 20/1 ratio containing definitely higher phosphate concentration than do their 5/1 ratio extracts, regardless of absolute value of P content, and

Soils which yield extracts at both 5/1 and 20/1 ratios of practically equal P content, neither extract containing more than 1.5 p.p.m. of P, are classed as deficient.

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[1] Univ. Ariz. Tech. Bull. No. 35 - October 15, 1931.

All other soils showing practically equal content of phosphate in both extracts are likely to respond to phosphate treatment and are classed as doubtful.

If one is to judge a method for determination of available phosphate by its ability to predict response to phosphate fertilization, he must find all methods proposed to date as failures, including field trials. The subject of response was discussed in the report on phosphate field trials made before this Society at Fort Collins in February 1939. Only a brief review will be given here.

Soils of Type A in which the 5/1 ratio extract contains more than 50% higher P concentration than does the 20/1 ratio extract are not likely to respond regardless of deficiency. These soils almost always require manure to produce good crops and since the soils have relatively little phosphate fixing capacity, the phosphate content of the manure can be depended on to supply the phosphate deficiency.

Very heavy soils yielding extracts of very low phosphate content at both 5/1 and 20/1 ratios are liable to show no response, because of capacity of the soil for reversion of added phosphate. Such soils can generally be identified by a high test for phosphate soluble in K_2CO_3 solution. As use of fertilizer drills which place the phosphate close to the seed becomes more common, response is expected to become more common on these soils.

Best response is to be found on the silt loam and clay loam soils, fairly high in $CaCO_3$, belonging to Type B.

A completely satisfactory explanation has not been offered for failure to get response on many carelessly farmed and non-rotated deficient testing fields. Deficiency is shown by too many methods to permit one to conclude that failure of these soils to respond means no deficiency of phosphate.

The evidence favors the acceptance of the principle of phosphate feeding efficiency. That is - on many good soils, generally of Type A, the plant obtains its phosphate requirements at a lower level of available phosphate than it is able to do on another soil giving similar test. When the soil is known to be a high yielder in spite of low phosphate test, there is no object in applying phosphate except to prevent depletion. Soils 4 and 6 in Table I gave similar tests. No. 4 is high yielding soil of a type noted for high quality, and does not respond to phosphate. No. 6 is not of a type equal to No. 4, and it produced excellent response. Well farmed soils of not high quality originally have been made to produce high yields and these soils of Type B phosphate test have shown even greater yield by phosphate fertilization.

We are satisfied that the acetate buffer extraction gives us a satisfactory measure of the level of available phosphate in the sample analyzed. The method fails to tell us how various factors will interact to change the level of available phosphate in the field during the growing season. Studies of this subject are being continued and it is hoped that a satisfactory basis for prediction of changes in available phosphate during the growing season may eventually be worked out. Today it appears that the safest practice is to sample the soil about August 1st and use the results on this sample as a guide for fertilizer treatment for the following season.

Standards for grading the Arizona soils have been set up using results of Neubauer tests on 12 representative soils of wide phosphate range as a guide. The results were so compatible among themselves that little difficulty was experienced in setting up standards. The present grading standards are:

All soils are classed as deficient which yield extracts at the 5/1 and 20/1 ratios either one of which contains less than 2.6 p.p.m. of P. Sufficient testing soils yield extracts both of which contain 4.0 (or more) p.p.m. of P. Soils giving intermediate tests are classed as doubtful. It is hoped that results of field trials may be available at some time to enable us to judge our standards, since Neubauer tests alone cannot be considered final.

TABLE I

RELATION OF EXTRACTABLE PHOSPHATE TO AVAILABLE PHOSPHATE
NORTHERN COLORADO AND WESTERN NEBRASKA SOILS

Soil No.	1		2		3		4	
Lab. No.	L-26		4435		4292		5851	
Soil Quality	Very fertile		Fertile		Poor		Fertile	
P_2O_5 by Field Trials	-		-		-		None	
Neubauer Test - Mg.P_2O_5/100 g.Soil	-		-		15.1		-	
Extractable Phosphate - Medium	Buffer	Water	Buffer	Water	Buffer	Water	Buffer	Water
Extraction Ratio:	Parts per Million of P in Extract							
1/2				0.10				
1/1		1.1						0.13
5/1	2.7	1.7	1.5		7.0		0.9	
10/1								0.18
20/1	1.8	0.95	0.8	0.25	3.5		0.6	0.14
50/1		0.50			1.6			

Soil No.	5		6		7		8	
Lab. No.	5858		4873		4877		4324	
Soil Quality	Fertile		Fair		Fair		Poor	
P_2O_5 by Field Trials	Slight Deficiency		Deficient		Deficient		-	
Neubauer Test - Mg.P_2O_5/100 g.Soil	-		-		-		1.4	
Extractable Phosphate - Medium	Buffer	Water	Buffer	Water	Buffer	Water	Buffer	Water
Extraction Ratio:	Parts per Million of P in Extract							
1/2								
1/1		0.13	0.5		0.4			
5/1	0.7		0.7		0.6		0.3	
10/1		0.11						
20/1	0.6	0.12	0.5		0.4		0.2	
50/1			0.4		0.2		0.1	

TABLE II

RELATION OF EXTRACTABLE PHOSPHATE TO AVAILABLE PHOSPHATE

WYOMING SOILS

Soil No.	1		2		3		4	
Lab. No.	5650-B		4248		4244		4246	
Soil Quality	Good		Good		Fair		Good	
P_2O_5 by Field Trials	-		-		-		-	
Neubauer Test - Mg. P_2O_5/100 g.Soil	-		5.1		4.9		3.6	
Extractable Phosphate - Medium	Buffer	Water	Buffer	Water	Buffer	Water	Buffer	Water
Extraction Ratio:	Parts per Million of P in Extract							
1/2								
1/1		0.23						
5/1	2.5		1.5		1.4		1.2	
10/1		0.25						
20/1	1.8	0.15	1.4		1.6		1.4	
50/1			0.8		1.0		0.9	

Soil No.	5		6		7		8	
Lab. No.	3572		4241		4242		0-6	
Soil Quality	Fair		Good		Good		Poor	
P_2O_5 by Field Trials	Deficient		-		-		-	
Neubauer Test - Mg.P_2O_5/100 g.Soil	3.0		2.2		1.1		-	
Extractable Phosphate - Medium	Buffer	Water	Buffer	Water	Buffer	Water	Buffer	Water
Extraction Ratio:	Parts per Million of P in Extract							
1/2								0.12
1/1								0.16
5/1	1.6		0.8		0.6		1.1	0.18
10/1					1.3			
20/1	1.5		1.8		1.8		2.5	0.13
50/1			1.3		1.4			

TABLE III

RELATION OF EXTRACTABLE PHOSPHATE TO AVAILABLE PHOSPHATE

SALT RIVER VALLEY (ARIZONA) SOILS

Soil No.	1		2		3		4	
Lab. No.	5875		5878		5874		5881	
Soil Quality	Excellent		Good		Poor		Poor	
P_2O_5 by Field Trials	-		-		-		-	
Neubauer Test - Mg. P_2O_5/100 g. Soil	10.5		6.9		5.5		3.1	
Extractable Phosphate - Medium	Buffer	Water	Buffer	Water	Buffer	Water	Buffer	Water
Extraction Ratio:	Parts per Million of P. in Extract							
1/2		2.8				0.24		0.05
1/1				0.40				0.07
5/1	15.0	1.9	4.3	0.85	6.0	0.44	1.5	0.25
10/1								
20/1	6.8	0.8	5.0	0.43	3.8	0.27	2.9	0.18
50/1								

Soil No.	5		6		7		8	
Lab. No.	5886		5884		5586		5609 (Calif.)	
Soil Quality	Poor		Poor		Good		-	
P_2O_5 by Field Trials	-		-		-		Deficient	
Neubauer Test - Mg. P_2O_5/100 g. Soil	1.3		0.9		-		-	
Extractable Phosphate - Medium	Buffer	Water	Buffer	Water	Buffer	Water	Buffer	Water
Extraction Ratio:	Parts per Million of P. Extract							
1/2								
1/1								
5/1	2.0	0.02	0.7	0.50	1.25		0.4	
10/1								
20/1	1.6	0.02	1.8	0.18	1.25		0.55	
50/1					1.2		0.7	

DRY SUBSTANCE BY DRYING

versus

DRY SUBSTANCE BY IMMERSION REFRACTOMETER

AS MEASURED IN THE NORMAL WEIGHT SOLUTION

F. R. Bachler

In the course of mutual control analyses of weekly composite samples collected in all the factories of the American Crystal Sugar Company and which were exchanged between, and analyzed by, the different laboratories, the outstanding disagreements were found to exist in the item of "per cent dry substance by drying".

Inasmuch as the true purity based upon dry substance by drying is used as one of the important criteria in judging individual factory efficiency, disagreements between the various laboratories in this item became a serious problem which finally resulted in raising the question as to "how true" the true purity can be when dry substance by drying at 105° C. could not be determined by the different chemists with at least the same degree of accuracy as is the case with the item of per cent sucrose by the Clerget method.

Relief in this respect came about in 1933 with the introduction of the normal weight solution method of analysis by the author in which all determinations are carried out in the same solution which must be prepared for polarization and with the decision, that henceforth in all of the factories of the American Crystal Sugar Company the immersion refractometrically determined dry substance was to replace the dry substance by drying at 105° C.

This move was justified not only because the refractometric dry substance of the control samples checked within even narrower limits than the polarizations but also because we were able to adduce proof that THE WEIGHT LOSS AT 105° C. WAS NOT SOLELY DUE TO LOSS OF MOISTURE BUT WAS ALSO DUE TO PROFOUND CHEMICAL CHANGES THAT OCCUR DURING DRYING WHICH RESULT IN AN APPARENT LOSS OF ACTUAL DRY SUBSTANCE showing, that the heretofore accepted method of dry substance by drying at 105° C. was giving too inaccurate results to warrant their use for the calculation of the "true" purity.

These dry substance losses we established by refractometric measurements and it is the purpose of this paper to describe our method of procedure and report on the results which have been obtained by drying at 105°. Another series of similar analyses comparing drying at 105° C. with drying in vacul at 60° C. with corresponding refractometric measurements will be reported upon their completion.

II.

The method of determining the dry substance of a product by drying rests upon the supposition that under the observance of the ordinary analytical precautions only free moisture is removed and that no weight consuming changes in the dry substance itself do occur.

If this supposition is true in the case of sugar products, then it should be possible within reasonable limits to find the same per cent of refractometric dry substance in a sample before and after drying.

To ascertain this point a series of experiments were made with products of different purity as collected in our different factories in which the following procedure was employed:

The sample was first made homogeneous by thorough mixing and kneading; two portions of 5.200 grams were then weighed out.

Portion A was made up of 100 ml. with distilled water of 20° C. A portion of this solution was refractometered at 20° C. The balance was clarified with a weighed portion of Horne's dry sub lead acetate and then polarized at 20° C.

Portion B was dried under carefully regulated strictly uniform conditions at atmospheric pressure at a temperature of 105° C. Constancy of weight was assumed to have been reached when two successive weighings agreed to within 0.05% dry substance. (In the case of molasses we ran very frequently against the condition that after a certain length of drying time the weight of the dried sample showed an increase rather than a decrease in weight).

The sand used for drying was acid and water washed, strongly heated, again washed and finally screened to uniform size. For each determination exactly 50 grams of sand were taken. In each case we added 5 ml. of boiling hot distilled water to facilitate uniform distribution of the sample within the sand. Thirty minutes of the pre-drying, followed by renewed stirring of the mixture, preceded the actual drying at 105° C. in the electrically heated oven which was automatically controlled to within ± 1° C.

In the case of molasses samples these were first thoroughly mixed, then de-aired by heating in a water jacketted funnel, screened through a fine mesh funnel, allowed to cool to room temperature and then analyzed. All analyses were made in duplicate and if the results did not agree closely, the test was repeated in its entirety.

The dry matter was then dissolved with boiling distilled water. The soluble portion was transfered to the same 100 ml. flask that was used for portion A, made up to 100 ml. at 20° C., refractometered at 20° C., clarified with the same weight of Horne dry lead as used in portion A and then polarized at 20° C.

On Table I are given the detailed results of one group of samples. On Table II are given summary results of analyses of similar products collected in widely separated localities and during different campaigns.

Table I

Comparing Refractometric Dry Substance with Dry Substance by Drying

A. Refractometric Dry Substance and Direct Polarization

	Item No.	White Fillmass			Intern. Fillmass			Raw Fillmass			Molasses		
		a	b	Avg.	a	b	Avg.	a	b	Avg.	a	b	Avg.
Grams of original product	1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
Refract. Scale Reading at 20°C	2	17.70	17.71	17.70	17.78	17.80	17.79	18.25	18.25	18.25	16.40	16.43	16.42
Grams of Refractometric dry substance	3	4.730	4.732	4.731	4.756	4.760	4.758	4.880	4.880	4.880	4.390	4.395	4.392
% Refractometric Dry Subst. on original product	4			90.98			91.50			93.84			84.47
% Direct Polarization	5	16.94	16.96	16.95	15.68	15.70	15.69	14.13	14.15	14.14	9.48	9.50	9.49
Gms. of direct polarization sucrose	6	4.404	4.410	4.407	4.077	4.082	4.079	3.674	3.679	3.676	2.465	2.490	2.467
Apparent Purity	7			93.15			85.72			75.32			56.16

B. Dry Substance by Drying and Direct Polarization

Grams of original product	8	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
Grams of dry substance	9	4.694	4.702	4.698	4.714	4.726	4.720	4.826	4.818	4.822	4.262	4.274	4.268
% Dry substance by drying on original product	10			90.34			90.77			92.73			82.04
% Direct Polarization (See note)*	11			16.95			15.69			14.14			9.49
Gms. of direct polarization sucrose	12			4.407			4.079			3.676			2.467
Apparent purity	13			93.80			86.41			76.23			57.80

C. Refractometric Dry Substance and Direct Polar. of Re-Dissolved Dry Subst.

Refractometric Scale Read. 20°C.	14	17.57	17.55	17.56	17.58	17.60	17.89	17.92	17.95	17.93	16.02	16.05	16.03
Gms. of Refractometric dry subst.	15	4.696	4.690	4.692	4.706	4.710	4.708	4.797	4.800	4.798	4.282	4.290	4.286
% Refractometric Dry Substance as if in original product	16			90.23			90.54			92.27			82.42
% Direct Polarization	17	16.74	16.78	16.76	15.34	15.36	15.35	13.65	13.70	13.69	9.10	9.15	9.12
Gms. of Direct Polarization Sucrose	18	4.352	4.363	4.358	3.998	3.994	3.991	3.549	3.562	3.554	2.366	2.379	2.371
Apparent Purity	19			92.88			84.77			74.07			55.31

Note: Items 11 and 12 same as 5 and 6

The difference between items 3 and 15 and items 6 and 18 afford a measure of the changes that occur during drying.

Oxnard, Cal. December 1939 (F.R.Bachler)

Table II – Comparison of Refractometric Dry Substance with Dry Substance by Drying

A. Refractometric Dry Substance and Direct Polarization

Item No.		Steffens House Raw Fillmass					Straight House Raw Fillmass					Steffens House Molasses					Straight House Molasses				
		Oxnard	Rocky Ford	Grand Island	Mason City	Average	Clarksburg	Missoula	E. Grand Forks	Chaska	Average	Oxnard	Rocky Ford	Grand Island	Mason City	Average	Clarksburg	Missoula	E. Grand Forks	Chaska	Average
	Total No. of Analyses	8	3	8	4	23	3	2	6	8	19	8	3	8	4	23	3	2	6	8	19
1	Grams of Orig. Product Taken	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
2	Refract. Scale Reading	18.23	18.07	18.06	18.08	18.11	18.43	18.42	18.22	18.21	18.32	15.61	16.27	16.17	16.07	16.03	16.26	16.37	16.11	16.17	16.23
3	Grams of Refr.Dry Subst.	4.872	4.825	4.824	4.836	4.839	4.927	4.919	4.876	4.867	4.897	4.183	4.356	4.326	4.300	4.290	4.352	4.373	4.314	4.322	4.340
4	Refr.Dry Subst.% Orig.Prod.	93.70	92.80	92.77	93.00	93.06	94.75	94.60	93.77	93.60	94.48	80.45	83.77	83.20	82.70	82.53	83.7	84.10	82.96	83.12	83.47
5	% Direct Polarization	14.20	14.81	14.36	14.21	14.39	14.63	14.83	14.27	14.11	14.46	9.56	10.65	10.28	9.60	10.02	9.90	10.12	9.65	9.33	9.75
6	Grams Direct Pol. Sucrose	3.692	3.850	3.734	3.695	3.725	3.804	3.857	3.710	3.670	3.760	2.486	2.769	2.673	2.499	2.606	2.572	2.631	2.509	2.426	2.534
7	Apparent Purity	75.7	79.7	77.4	76.4	77.0	77.2	78.4	76.1	75.4	76.8	59.4	63.5	61.7	58.1	60.7	59.1	60.1	53.1	56.1	58.4
	B. Dry Substance by Drying and Direct Polarization																				
8	Grams of Orig.Product Taken	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
9	Grams of Actual Dry Subst.	4.782	4.735	4.732	4.731	4.745	4.803	4.809	4.672	4.729	4.753	4.029	4.273	4.229	4.103	4.158	4.169	4.216	4.120	4.126	4.158
10	% Dry Subst. on Orig. Prod.	91.96	91.05	91.00	90.98	91.25	92.36	92.48	89.84	90.94	91.40	77.48	82.17	85.33	78.90	79.96	80.17	81.07	79.23	79.34	79.96
11	% Direct Polarization	14.20	14.81	14.36	14.21	14.39	14.63	14.83	14.27	14.11	14.46	9.56	10.65	10.28	9.60	10.02	9.90	10.12	9.65	9.33	9.75
12	Grams direct Pol. Sucrose	3.692	3.850	3.734	3.695	3.725	3.804	3.857	3.710	3.670	3.760	2.486	2.769	2.673	2.499	2.606	2.572	2.631	2.509	2.426	2.534
13	Apparent Purity	77.2	81.3	78.9	78.1	78.5	79.2	80.2	79.4	77.6	79.1	61.7	64.8	63.2	60.9	62.7	61.7	62.4	60.9	58.8	60.94
	C. Refractometric Dry Substance and Direct Polarization, Determined on Above Re-Dissolved Dry Substance by Drying																				
14	Refractometric Scale Reading	17.97	17.66	17.67	17.82	17.75	18.12	18.07	17.94	17.90	18.02	15.17	15.52	15.57	14.44	14.44	15.67	15.93	15.45	15.73	15.71
15	Grams of Refr. Dry Subst.	4.803	4.725	4.726	4.766	4.755	4.841	4.829	4.788	4.786	4.811	4.063	4.154	4.172	4.131	4.130	4.193	4.267	4.141	4.206	4.207
16	Refr.Dry Subst.% Orig.Prod.	92.41	90.85	90.95	91.68	91.47	93.12	92.85	92.15	92.05	92.53	78.12	79.85	80.25	79.45	79.41	80.85	82.12	79.65	80.85	80.86
17	% Direct Polarization	13.80	14.03	13.78	13.77	13.79	14.17	14.34	13.85	13.70	14.01	8.90	9.73	9.44	8.80	9.22	9.18	9.39	8.88	8.59	9.01
18	Grams Direct Pol. Sucrose	3.588	3.648	3.583	3.580	3.600	3.684	3.728	3.601	3.561	3.643	2.316	2.530	2.453	2.289	2.397	2.382	2.441	2.310	2.233	2.341
19	Apparent Purity	74.7	77.2	75.8	75.1	75.7	76.1	77.2	75.2	74.4	75.7	57.0	60.9	58.8	55.4	58.0	56.8	57.2	55.8	53.1	55.7

Note: Items 11 and 12 are same as items 5 and 6
The difference between items 3 and 15 and items 6 and 18 afford a measure of the changes that occur during drying.

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(F. R. Bachler)

III. Discussion of Results

Had no loss of dry substance or decomposition changes occurred during drying, then the average refractometric weight of dry substance as determined in portion A (Table I, Item 3) and that of the re-dissolved dry substance of portion B (Table 1, Item 15) should have been very nearly equal. We find, however, that during drying at 105° C. happened, a decided loss of refractometric dry substance as is shown by the following figures:

	Total grams of Refractometric Dry Sub. lost	Loss in % on Refr. Dry Sub. of Sample A
White Fillmass	0.039	0.82
Intermediate Fillmass	0.050	1.05
Raw Fillmass	0.082	1.68
Molasses	0.106	2.42

At the present stage of these investigations, we are looking upon these refractometric dry substance losses as a closely approximate measure of the sum total of actual dry substance losses which occur during drying at 105° C.

In regular analytical procedure we would ordinarily compare the refractometric dry substance of the original product with the dry substance by drying of the original product and in doing so obtain the following comparisons:

	White Fillmass	Inter. Fillmass	Raw Fillmass	Molasses
Grams of Refrac. Dry Subst(item 3)	4.731	4.758	4.880	4.392
Grams Dry Subst. by drying (item 9)	4.698	4.720	4.822	4.268
Dry Subst. by drying is smaller	.033	.038	.058	.124
Diff. in % on Refr. Dry Subst.	0.69	0.79	1.18	2.82

These differences are large enough to cause appreciable variations in purity as seen in the following comparison:

	White Fillmass	Inter. Fillmass	Raw Fillmass	Molasses
Appar. Purity by Refr. (item 7)	93.15	85.72	75.32	56.16
Appar. Purity Dry Subst. (item 13)	93.80	86.41	76.23	57.80

The analyses show that the removal of moisture by drying at 105° C. is accompanied by a far reaching decomposition of original solid matter which becomes manifest by appreciably lowered polarimetric and refractometric readings.

These losses appear smallest in the white fillmass and are greatest in the final molasses. Taken as a whole, they are lower in non-Steffens than in Steffens houses.

It cannot be gainsaid that the effects of heat and time during drying become manifest in two directions; the one resulting in a direct loss of dry matter due to volatilization of some of the solid constituents, the other of causing changes in the refractive indices of some of the solids. These refract-

ive changes when going in one direction would tend to simulate a loss, or, if going into the other direction, indicate a gain. For these reasons the refractometrically determined dry substance losses must, in the meantime, merely taken as proof that the official method of determining dry substance by drying at 105° C. is not dependable and that, therefore, the "true purity" based thereon is in reality quite far from the truth.

Work, which is underway, (but which is not yet supported by a large enough number of analyses of low purity products) indicates, that dry substance determined by drying in vacuo at 60° C., and the refractometric dry substance as determined immersion refractometrically by the Oxnard normal weight solution method, show a very close agreement when checked by the above described method.

Theoretical yield calculations of fillmasses based upon the refractometric dry substance purity agree very closely with actual yields. This feature, we hold, is the best proof for the dependability of the refractometric method of analysis over the double dilution Brix, or the dry substance by drying, method of analysis.

THE RELATIONS EXISTING BETWEEN pH MEASURED IN THE LABORATORY AT 25° C. AND THE pH OF THE SAME SOLUTION AT THE EXISTING OPERATING TEMPERATURES IN THE FACTORY

F. R. Bachler

I.

The occurrence of unseemly high percentages of invert sugar in the final molasses is at times observed in every beet sugar factory. Aside from the accidental possibility now and then of a distinctly acid pH condition during some phase of the process, it often cannot be readily understood why invert sugar should occur in what may by some be considered to be a safely pH alkaline house.

A clue as to the principal source of such invert sugar occurrences can be had only from a systematic and often very protracted invert sugar survey which must begin with the thin juice and end with the molasses, including all intermediate steps in the process. When invert sugar is found at all it will nearly always show up in the thick juice first, yet practically never will there be any invert sugar in the thin juice entering evaporators. From the thick juice stage on there will, likely, be found relatively little additional invert sugar provided, of course, that the pH of the white fillmass was not allowed to drop below pH 7.5 and that of the succeeding fillmasses not below pH 7.3.

From these observations we conclude that the bulk of the invert sugar found in the molasses originates from thick juice. Since the thin juice entering the evaporators was free from invert sugar it follows that all the invert sugar in the thick juice was formed during evaporation. By further extending our search to the juices of the different evaporator bodies, we find that approximately 78% of the invert sugar in the thick juice originated in the first body, about 20% were formed in the second body and the remainder of 2% was formed in

the third body. Very likely none was formed in the fourth or fifth bodies of evaporators.

We know that the rate of inversion of a pure sugar solution is a function of pH, heat, time, and concentration of same. In the case of an impure sugar solution must be added another, in its effects as yet not so well known but, nevertheless, very important factor, that of the character and the quality of the non-sugars, "buffer substances", that are present. As regards the latter we know that with all other inversion promoting conditions being equal, the rate of inversion in general will become slower the more buffer substances are present; we also know that a given weight of a certain non-sugar, or group of non-sugars, will influence the rate of inversion differently than would be that if a similar weight of another non-sugar or group of non-sugars were present.

Of the five factors which govern the rate of inversion of the thin juice entering the evaporators we can definitely control only akalinity, respectively, pH. Before the advent of pH control it was considered safe practice that the thin juice entering evaporators should be at least faintly akaline to phenolphthalein and if the thick juice leaving the evaporators did not show a faint pink, but happened to be colorless to phenolphthalein, then the akalinity of the thin juice would be raised slightly until the thick juice left the evaporators at least faintly alkaline to thick juice. Experience had shown that under such conditions sugar losses due to inversion during evaporation did either not occur at all, or were so small as to be negligible. If it so happened that either an undue rise, or fall, of alkalinity occurred during evaporation then this was considered a sign that errors had been committed during the purification stages of the process and all efforts were bent toward removing the cause of this unusual behavior.

With the advent of pH control it was realized that the point at which phenolphthalein changed color was at pH 8.2 - 8.3 and it became the practice for awhile to hold the pH of the thin juice entering evaporators at that figure, or a little higher if a loss of pH occurred during evaporation. Gradually the operators receded from this point and felt justified in doing so because thin juice of a pH lower than 8.2 - 8.3 boiled faster in the evaporators and that the subsequent fillmasses too may have boiled and purged easier; and if it so happened that during such a campaign there was practically no invert sugar produced even though the pH of the thin juice entering evaporators was held as low as pH 7.5 - 7.6, then this was considered by that factory, and maybe a number of other factories, as an example to emulate during next campaign. If in the succeeding campaign in that, or a different factory, the same pH of thin juice resulted in a more or less heavy invert sugar production, then the cause thereof was, as a rule, not assigned to having started out with too low a pH but that "the beets this year were peculiar", which is true in a way, considering what baleful effects a slight change in the character of the non-sugars may produce as regards the physical and chemical behavior of the juices in the house.

The beet sugar factory laboratory technic of determining pH closely followed the scientific development of the art; thus the colorimetric drop method was followed by the likewise colorimetric test tube method which was replaced by methods that measure the electric potential existing between the juice and metal to metal oxide electrodes of the antimony type. The change from one method to another was due to a gradual realization of serious shortcomings inherent to that method. Thus for instance, the colorimetric methods

suffer from serious errors due to temperature, the solvent, salt, protein and colloid effects; that of the calomel half cell antimony electrode types, while free from some of the errors of the colorimetric methods, are fast being recognized of giving inaccurate results due to the presence of chemical substances in the beet juices which react with the antimony oxide such as SO_2, or certain organic acids or organic salts, which form complexes with the antimonous oxide. This knowledge of the limitation which the various methods of determining pH imposed was acquired in the beet sugar laboratory gradually and by the hard way of an ever widening bitter experience which served to increase the desire for a method, or an instrument, which would not be affected by the limitations above cited. Such an instrument, as every chemist knew, would be one equipped with glass electrodes but in view of the extreme fragility of these electrodes this remained a pious wish until about a year ago when the present rugged Beckman electrodes appeared.

In the meantime some factories had adopted continuously indicating pH instruments of the antimony type, the electrodes of which were immersed in a flow through chamber through which flowed a continuous stream of the hot juice as existing in the house. These instruments did not indicate the pH of the juice at the existing temperature but the pH as would be found had the juice been cooled to 25° C. When the pH indications of this factory instrument were compared with the pH value of the laboratory antimony instrument on the same juice but which had been cooled to 25° C., then, as a rule, a fairly close agreement was found which served for a time to confirm the faith in the accuracy of the pH value as determined by these antimony instruments.

This faith was due for a rude awakening, for now enters the Beckman Glass Electrode pH Indicator as a house control device. Intending to use the Beckman instrument for the control of pre-defecation, we placed one such instrument at Oxnard side by side with an L&N antimony continuous pH indicator, both instruments using exactly the same juice. It was our original intention to check the pH indicators of the Beckman instrument against those of the L&N. We expected to find a very close agreement and were quite surprised, when we found that a very large difference in the indicated pH values existed. The cause of this difference was found to be due to the basic fact that the Beckman instrument indicated the pH as it exists at the actual factory temperature, while the L&N antimony instrument indicates the pH value corrected by an inbuilt device which checks within fairly close limits with the pH of the laboratory antimony instrument, which measures the pH juice cooled to 25° C. This fact was definitely established by experts of the National Technical Laboratories, who measured the pH of the juice hot and cold with a hydrogen electrode, the results of which were found to check within $\pm$ 0.02 pH with those as found by the glass electrode.

The fact that the Beckman factory glass electrode pH as measured on first carbonation juice at a temperature of 85° C. was lower by 1.2 pH than that obtained by the L&N factory antimony instrument was too significant to be overlooked. It led us to a somewhat closer study of the pH conditions as these actually exist at the prevailing elevated temperatures in the house in comparison with those which were found in the laboratory on the same juices cooled to 25° C. and this paper is a resume of the results of this study.

II.

Our intital attempts to measure these differences with our regular antimony laboratory instrument led to no satisfactory results. The answer to our problem was found in using the Standard Industries Model M. Beckman Glass Electrode pH Meter which, by virtue of the chemical inertness of the glass electrodes, is free from the chemical inhibitions that mitigate against the obtaining of accurate results with the antimony electrode. A special Beckman glass electrode, recently developed, suitable for working ranges up to 100° C. was used in conjunction with the standard instrument for the high temperature pH measurements. The comparison calomel electrode employed was the standard Beckman type.

In working the comparative tests between the pH of the hot and the cold juice it was not practical to use a single set of electrodes for both sets of measurements. A more practical way was to use two sets of electrodes, the special high temperature electrode for hot and the regular standard electrode for cold pH measurements with a separate calomel electrode for each. It was thus a simple matter, necessitating merely withdrawing the plugs of one set of electrodes and inserting those for the other electrodes in order to change from a hot to a cold pH measurement. While making a series of determinations, the particular electrode set not in use was kept immersed in either water, juice or buffer solution of a temperature corresponding to that of the juices to be measured. In this manner both sets of electrodes were at all times instantly ready and in proper temperature equilibrium.

The pH meter was standardized with the electrodes against a pH 7.0 phosphate buffer. Since this particular buffer solution changes but very slightly with temperature (less than 0.05 pH over the entire range between room temperature and 100° C.) it was particularly well adapted to this investigation as the same buffer could be used as a reference standard for the instrument with both the high and the low temperature electrodes at their working temperatures.

Two series of tests were always made in which the pH of the juice at high temperatures, approximately that prevailing under actual operating conditions, was determined and compared directly to that as determined on identically the same sample after cooling same to 25° C. The pH at the high temperature IS THE ACTUAL pH OF THE JUICE IN THE PROCESS AT THE EXISTING TEMPERATURE, whereas the pH of the second test, that of the cooled juice, corresponds to the pH obtained at the usual laboratory test which, so far, WE HAVE PRESUMED TO BE INDICATIVE OF THE ACTUALLY EXISTING OPERATING pH.

(Incidentally with the studies on temperature effect here reported another study is in progress comparing the results obtained in the laboratory by measuring the pH of the same juice at room temperature, using the glass and the antimony electrode instruments. While this study is far from being complete, the results obtained so far throw a dark shadow of doubt on the dependability of the pH values obtained from the antimony electrode system. We mention this here because the need of investigating these two methods of pH determination originated from our early, though futile, attempts to study the effects of pH by high and low temperatures with our laboratory antimony instrument).

Knowing that large pH differences existed, we were desirous of finding out first of all whether or not a constant relationship existed between the pH of the juice at its working and at its laboratory temperature and, if such a relationship did exist, to find out if it were possible to apply to the laboratory determined pH value a constant correction factor so as to correct it to the pH as existing at the actual working temperature; also to determine, if it were possible to do so, if inversion of sucrose would occur in a juice that was pH alkaline when cold but pH acid when hot.

All measurements were made during the latter half of 1939 campaign in the Oxnard Laboratory of the American Crystal Sugar Company by Mr. F. W. Weitz and Mr. Arthur Lorenz. While the data presented are by no means complete, being more in the nature of a preliminary survey, these do reveal highly significant facts of which immediate cognizance had to be taken in the interest of better factory control.

The first series of tests was devoted entirely to thin juice entering evaporators. An overflow type electrode chamber was connected with the sample line of juice to evaporators and a constant flow of juice was allowed to flow through. The temperature of the juice at this point averaged 96° C. During these tests the high temperature electrodes were inserted in the flow-through electrode chamber and kept immersed in the stream of juice. Hence the set was available and ready for a test at any time merely by plugging into the instrument.

Whenever a reading was made on the hot juice, a portion of the juice overflowing at that moment was collected in a small bottle, quickly cooled in a water bath, and then used for the corresponding comparative cold test. In this manner a considerable number of tests were made and compared at frequent intervals. The results of this group of tests, made on several successive days, are tabulated and shown in the accompanying table headed "Comparative Tests of pH of Thin Juice at 96° and 25° C.

In the second series the scope of the tests was expanded to take in other juices. In this group of tests the pH at high and low temperatures was compared on first and second carbonation juices, thin juice, thick juice, and first liquor. Unlike the previous series, in which the tests were made directly at the station, the tests in this group were made entirely in the laboratory. Portions of the regular routine test samples brought to the laboratory were used for these special tests. The test portions, in groups of five, were first heated on the hot plate to a uniform temperature of 98° C. The electrodes, which in the meantime, and during the interval between tests, had been brought to and kept at the proper working temperature by being suspended in buffer solutions of pH 7.0 at 98° C., were immersed into the test solution and the readings of the five samples in the group being taken consecutively. The samples were then quickly cooled and the corresponding cold pH measurement made. This series of tests, too, was extended over a number of days to obtain varying juice conditions and several groups of tests were made on each of these days. The samples thus tested probably covered a representative range of average juices produced during that period. The results of these tests are given in the second table.

Before entering into a discussion of the results obtained in these tests, we will briefly describe another series of exploratory tests in which we attempted to ascertain if a thin juice of a given cold and hot pH would show signs of inversion if kept boiling for a measured period of time. For this purpose we determined pH hot and cold at the commencement of the boiling period and again after thirty minutes of continuous boiling on the hot plate. We also determined the invert sugar at the beginning and at the end of the boiling period.

The following results were obtained:

	I	II	III	IV
pH at 25° C. at beginning of boiling period	8.3	7.8	7.5	7.3
pH at 25° C. at end of boiling period	8.2	7.6	7.3	6.9
pH at 98° C. at beginning of boiling period	7.4	7.0	6.6	6.4
pH at 98° C. at end of boiling period	7.3	7.0	6.4	6.1
Invert sugar before boiling - % on Dry Subst.	None	None	Trace	Strong Trace
Invert sugar after boiling - % on Dry Subst.	None	Trace	0.22	0.39

Crude as was the arrangement of those tests, they do show, nevertheless, that inversion does occur if the pH of the hot juice is on the acid side and that inversion becomes the greater the lower the pH. Similar results were obtained in the house. In these laboratory tests, in reality, the pH of the boiling just must have been lower still, because the measurements were made at 98° C., while the juice was boiling at 101.5° to 102° C. In the first body of evaporators, where temperatures as high as 115° C. exist, the actual pH will be still lower and the inversion losses be very likely even higher. A systematic survey needs to be made on the changes in pH, measured hot and cold, on the juices as these enter and leave the various evaporator bodies. Much could be learned from such a study if the pH values were plotted against evaporation time in each body, changes in temperature and concentration as these occur in the different bodies.

We will now briefly discuss the results reported on the two tables. A study of the data reveals at once that a distinct and measurable difference exists between the pH of the juice at its process temperature and that of the same juice cooled to 25° C. The pH at the high temperatures is appreciably lower than that of the cold juice. It would be very convenient if this difference were a constant, because this would enable us to correct observed readings at room temperature to obtain the pH of the same juice at actual working temperature. Unfortunately, however, our observations show that such a simple and convenient relation does not exist but that rather, at different times, as the character of the juice changes, the pH difference due to temperature also changes.

In the case of our observations on thin juice, covering 98 tests, we found that the pH as measured at 96° C. was fairly constant, varying only between 7.2 and 7.45. When the pH of the same juice was measured at 25° C., more and larger fluctuations were shown and the pH varied from 7.7 as a minimum to 8.45 as a maximum, or a total spread of 0.75 pH.

This spread on the cold pH, however, only partially reveals the actual pH differences, as in many instances the maximum cold pH was obtained on tests in which the pH hot was on the low point. In such cases a difference in pH at the two respective temperatures of as much as 1.15 was shown. On the other hand, a difference as low as 0.5 pH was obtained in other tests. The average difference of all tests made on thin juice was 0.9 pH. With extreme variations from 0.5 to 1.5 pH it would hardly be feasible to safely apply the average difference as a correction factor to convert observed readings at room temperature to what may be the true pH at operating temperatures.

The second series of tests, which was extended to cover other juices in addition to thin juice, corroborated the findings in the first series. Again we found that the higher temperature the pH of the juice was lower than when determined after cooling, with the difference varying from as little as 0.5 to as much as 1.6 pH.

COMPARATIVE TESTS OF pH OF THIN JUICE AT 96° AND AT 25°

Time	pH 96°	pH 25°	Difference
(Date)	October 1, 1939		
10:02	7.3	7.9	.6
04	7.2	7.7	.5
06	7.2	7.75	.55
08	7.2	7.8	.6
10	7.25	7.85	.6
12	7.25	7.8	.55
14	7.2	7.75	.5
16	7.2	7.8	.6
22	7.2	7.85	.65
26	7.2	7.95	.75
30	7.25	8.0	.75
33	7.25	8.1	.85
35	7.3	8.2	.9
38	7.3	8.15	.85
41	7.3	8.15	.85
44	7.25	8.05	.8
47	7.2	7.9	.7
50	7.2	7.75	.55
53	7.2	7.8	.6
55	7.2	7.8	.6
58	7.2	7.85	.65
11:00	7.2	7.9	.7
03	7.2	7.9	.7
05	7.2	7.95	.75
08	7.25	8.0	.75
11	7.25	8.0	.75
13	7.3	8.1	.8
16	7.3	8.15	.85
18	7.35	8.15	.8
22	7.35	8.2	.85
26	7.35	8.25	.9
30	7.4	8.25	.85
33	7.35	8.15	.8
11:35	7.3	8.15	.85
39	7.4	8.25	.85
42	7.45	8.3	.85
45	7.45	8.3	.85
47	7.45	8.35	.9
50	7.4	8.3	.9
53	7.35	8.25	.9
56	7.35	8.25	.9
59	7.4	8.25	.85
12:35	7.4	8.25	.85
37	7.4	8.25	.85
40	7.4	8.3	.9
43	7.4	8.3	.9
45	7.4	8.3	.9
47	7.4	8.35	.95
50	7.4	8.35	.95
53	7.4	8.3	.9
56	7.4	8.3	.9
1:00	7.4	8.25	.85
04	7.4	8.25	.85
07	7.4	8.25	.85
09	7.4	8.25	.85
11	7.4	8.25	.85
13	7.4	8.25	.85
15	7.4	8.25	.85
18	7.4	8.3	.9
20	7.4	8.3	.9
25	7.4	8.3	.9
32	7.4	8.35	.95
34	7.45	8.4	.95
39	7.45	8.45	1.0
43	7.45	8.45	1.0
45	7.45	8.45	1.0
48	7.45	8.45	1.0
(Date)	October 2, 1939		
9:15	7.2	8.2	1.0
17	7.2	8.2	1.0
20	7.2	8.3	1.1
23	7.2	8.3	1.1
25	7.25	8.35	1.1
29	7.25	8.35	1.1
32	7.2	8.3	1.1
35	7.2	8.3	1.1
38	7.2	8.3	1.1
40	7.2	8.3	1.1
46	7.2	8.3	1.1
49	7.2	8.25	1.05
53	7.25	8.3	1.05
56	7.25	8.4	1.15
10:00	7.35	8.45	1.1
05	7.35	8.45	1.1
09	7.35	8.45	1.1
13	7.3	8.45	1.15
17	7.3	8.45	1.15
20	7.3	8.4	1.1
25	7.3	8.4	1.1
(Date)	October 3, 1939		
10:15	7.2	8.2	1.0
19	7.25	8.3	1.15
22	7.3	8.35	1.05
25	7.3	8.4	1.1
28	7.25	8.4	1.15
31	7.25	8.4	1.15
35	7.35	8.4	1.05
39	7.35	8.4	1.05
42	7.35	8.4	1.05
45	7.35	8.4	1.05

Average of above 98 tests
pH at 96° 7.3
pH at 25° 8.2

Maximum difference 1.15
Minimum difference .5
Average difference .9

Tests made with Beckman Industrial Model M pH meter glass electrode. Special high temp. electrode used for tests at 96°. The above tests were made at the evaporator station.

Oxnard, Calif.
1939 Campaign.

Comparative Tests of pH at 98° and at 25°

Date	First Carb. Juice After Filters pH			Second Carb. Juice After Filters pH			Thin Juice Entering Evaporators pH			Thick Juice Leaving Evaporators pH			First liquor to Pan Storage pH		
	98°	25°	Difference	98°	25°	Difference	98°	25°	Difference	98°	25°	Difference	98°	25°	Difference
Oct. 28	9.8	10.7	.9	7.9	9.1	1.2	7.2	8.1	.9	6.6	7.3	.7	6.7	7.3	.6
	9.7	10.5	.8	7.7	8.9	1.2	7.2	7.7	.5	6.7	7.4	.7	6.5	7.2	.7
	9.7	10.6	.9	7.7	8.9	1.2	7.0	7.9	.9	6.5	7.3	.8	6.5	7.2	.7
Oct. 29	9.3	10.7	1.4	7.6	8.9	1.3	7.0	7.9	.9	7.0	7.5	.5	6.8	7.3	.5
	9.4	10.7	1.3	7.5	8.7	1.2	7.1	7.9	.8	6.9	7.6	.7	6.6	7.3	.7
	9.5	10.7	1.2	7.4	8.8	1.4	7.1	8.0	.9	7.0	7.9	.9	6.8	7.6	.8
	9.2	10.5	1.3	7.6	8.9	1.3	7.1	7.8	.7	6.6	7.2	.6	6.6	7.1	.5
Oct. 30	9.0	10.6	1.6	7.6	9.0	1.4	6.9	8.0	1.1	6.6	7.3	.7	6.4	7.2	.8
	9.1	10.7	1.6	7.4	8.9	1.5	6.9	7.9	1.0	6.7	7.7	1.0	6.5	7.3	.8
Oct. 31	9.2	10.6	1.4	7.6	9.1	1.5	7.0	8.0	1.0	6.8	7.5	.7	6.7	7.6	.9
	9.3	10.7	1.4	7.6	8.9	1.3	6.9	7.9	1.0	6.6	7.2	.6	6.5	7.3	.8
	9.2	10.6	1.4	7.6	8.9	1.3	7.0	8.2	1.2	6.7	7.3	.6	6.5	7.5	1.0
Nov. 1	9.4	10.9	1.5	7.6	9.0	1.4	6.9	7.4	.5	6.7	7.4	.7	6.6	7.4	.8
	9.4	10.7	1.3	7.7	8.9	1.2	6.9	7.6	.7	6.5	7.3	.8	6.4	7.2	.8
	9.4	10.6	1.2	7.7	8.9	1.2	7.2	8.0	.8	6.6	7.4	.8	6.5	7.0	.5
Nov. 8	9.2	10.7	1.5	7.4	8.7	1.3	7.2	8.2	1.0	6.9	8.0	1.1	6.5	7.6	1.1
	9.1	10.6	1.5	7.4	8.6	1.2	6.8	8.1	1.3	7.0	8.2	1.2	6.7	7.9	1.2
Nov. 9	9.2	10.5	1.3	7.5	8.6	1.1	7.0	7.7	.7	6.9	7.7	.8	6.8	7.6	.8
	9.3	10.8	1.5	7.6	8.7	1.1	7.1	8.0	.9	6.9	7.8	.9	6.9	7.6	.7
	9.3	10.7	1.4	7.6	8.8	1.2	6.9	7.8	.9	6.9	7.8	.9	6.8	7.7	.9
	9.4	10.8	1.4	7.6	8.8	1.2	7.1	8.2	.9	6.9	7.9	1.0	6.9	7.8	.9
	9.3	10.6	1.3	7.6	8.8	1.2	7.0	7.9	.9	6.8	7.5	.7	6.6	7.4	.8
Max.Diff.(22 tests)			1.6			1.5			1.3			1.2			1.2
Min.Diff. " "			.8			1.1			.5			.5			.5
Av.of 22 tests	9.3	10.7	1.4	7.6	8.9	1.3	7.0	7.9	.9	6.8	7.6	.8	6.6	7.4	.8

Tests made with Beckman Industrial Model M pH meter, glass electrode.
Special high temperature glass electrode used for tests at 98°.
For high temp. tests the samples were heated on laboratory hot plate.

Oxnard, Calif.
1939 Campaign.

It was noted further that in the higher average pH ranges the spread between the pH of the hot and the cold juice was greater than in the lower ranges. Thus, on first carbonation juice with an average pH of 9.3 determined hot and pH 10.7 determined cold, the average difference was 1.4 pH. On second carbonation juice the average difference was slightly less, 1.3 pH. In the lower pH products, thick juice and first liquor averaged respectively 6.8 and 6.6 pH while hot, and 716 and 7.4 pH while cold, the average difference for temperature change being 0.8 pH. The tests on thin juice gave an intermediate difference of 0.9 pH, which, it is interesting to note, substantiated the average difference found in the first series of tests on thin juice alone.

As noted before in the case of thin juice, the difference in pH between hot and cold test on any one product is not a constant. The difference varies from hour to hour, and even more so from day to day, as the nature and the character of the juice changes. The difference, therefore, can be considered in a rough way as an approximate correction factor to estimate from the cold pH as determined in the laboratory what the actual pH may be in the process.

The fact that the difference in pH between the hot and the cold test on any one kind of juice is not a constant factor is explainable on the grounds of changes in character of the juice itself. As the beets from different localities, and even from different fields in the same locality, change in composition, so must the juice also change in character. The amount and the nature of both the organic and inorganic constituents are constantly changing. To this we must add the widely varying quality of the first carbonation juice as is obtained from the Dorr continuous carbonation process, which is a mixture of perfectly carbonated, over-carbonated, and raw juice, the proportions of which are constantly changing, and even though these juices show what appears to be the desired pH, are, nevertheless, quite widely differing in quality. Since the effect of temperature on the potential difference set up between the electrodes varies with different salts, the change in pH due to temperature differences in the juice constantly changing in character, must necessarily be a pH fluctuation-causing factor.

Those pH fluctuations in the juice as observed at Oxnard are not necessarily wholly applicable to conditions in other houses, especially if those be non-Steffens houses using batch (instead of continuous) carbonation, just as a certain set of conditions existing in a previous campaign may not necessarily be successfully applicable to other campaigns or in other factories.

This leads us to a consideration of the point as to what real value we can attach to the laboratory records of pH measurements at 25° C. when we now positively know that the real operating pH at the existing house temperature is radically different.

Undoubtedly, a better understanding of these conditions will lead to a more rational work in the house by helping us to fight adverse conditions more intelligently than we have been able to do thus far under the assumption that the laboratory determined pH of the cold juice was a dependable criterion.

It seems that the solution of the problem will be found in the installation at various strategic points in the house of Beckman Glass Electrode continuous pH Indicators for the immediate guidance of the operators and in the laboratory by substituting the presently used colorimetric or the potentiometric antimony pH instruments with the Beckman type Glass Electrode pH Instruments.

The matter of cost of replacing these laboratory instruments should not be looked upon as an insuperable item, for it is easy to see that inaccurate or faulty equipment may lead to errors in the manufacturing process which could on any one day be far more expensive than the cost of such an instrument. Neither can there be an argument on the ground that if the antimony electrodes have been found to give faulty results, that there is no assurance that the same may not happen with the glass electrode instruments, for today the industry at large knows positively that the glass electrode is the logical first choice because of its wide pH range, freedom of scale errors, freedom of poisoning and for the easy reproductibility of its results, and that its pH indications check under all working conditions within extremely narrow limits with the pH values as determined with the hydrogen electrode which, after all, is the ultimate standard against which the values found by all other pH instruments, or methods, are referred to.

SUMMARY

Report is made of an investigation undertaken in the Oxnard factory laboratory of the American Crystal Sugar Company during campaign 1939 on the pH values of various beet sugar factory products if these are measured, as is customary, at room temperature or at the actually existing factory temperatures.

Method of procedure and description of equipment used is given.

It was found that the actual pH of the juices at, or near, the process temperatures is very appreciably lower than that of the same juices if measured at 25° C.

It was found experimentally at first and later confirmed under factory conditions, that when the laboratory pH value seemed to be well above pH 7.0, that such juices at boiling temperatures may be well below pH 7.0 and may suffer serious inversion losses.

The hope of finding a constant correction factor to be applied to the laboratory determined pH values so that a measure be had as to what the actual operating pH may be, did not materialize.

The results obtained so far throw a heavy shadow of doubt on the reliability of the pH results as presently determined at room temperature as to their value of being a dependable guide to the operators.

The recommendation is made that glass electrode pH indicating instruments be placed into strategic positions in the house and that the laboratory control be carried out with similar instruments.

LOSS OF NUTRIENTS FROM BEET TOPS

DURING STORAGE IN PILES IN THE FIELD
(Demonstration Paper)

Robert J. Brown
Great Western Sugar Company
Research Laboratory

Drying of beet tops has been recommended to prevent loss of nutrients from beet tops during storage in the field. The test herein reported was executed to determine the magnitude of the storage loss.

Beet tops were collected very soon after the beets had been topped. They were immediately distributed in piles containing one hundred tops each, each pile resembling all others as nearly as possible. Each pile was placed on a piece of burlap to permit recovery of 100% of the contents of the pile when time for sampling arrived. Weights or original tops in each pile were determined and the piles were placed in the field. The weights of tops in the piles averaged 51 pounds each.

Immediately after building the piles, two of them were rolled, quartered and the samples were weighed and taken to the laboratory immediately and dried. Crowns were cut from the leaves, chopped into small pieces and dried in an oven. The leaves were dried in a rotating drum drier, through which a stream of heated air was passed, and were practically completely dried in three hours. The loss of nutrients between the time the beets were topped and the time the tops were dried could not have been appreciable. Crowns and leaves were analyzed separately and the analyses were calculated to original tops.

The composition of each pile was calculated from the weight of original tops placed in the pile and the average analysis, on original tops, of the two original samples. That the piles were not perfectly uniform was shown by the fact that ash content of the original samples varied by 20%, protein varied 7%, and crude fiber and nitrogen free extract varied less than 1%. The large variation in ash was probably the result of varying quantities of soil in the leaves.

Periodically a previously untouched pile was weighed, rolled, quartered and the sample was weighed. After analysis of the sample the content of the pile in the various components was calculated.

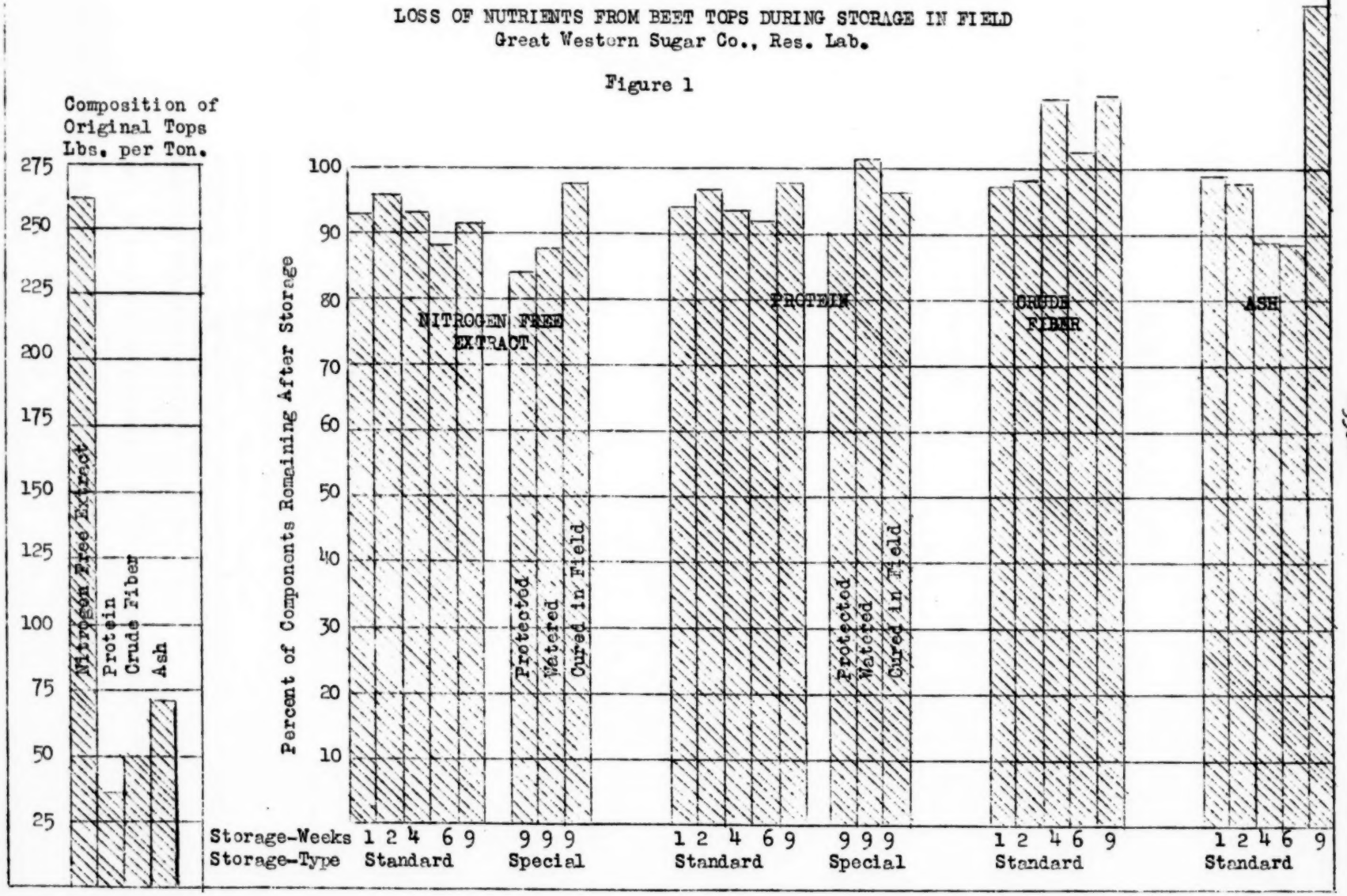
Most of the effort was directed toward determination of loss in piles under climatic conditions as they existed during the test. Three special tests were also carried out. In one, the piles were protected from precipitation by covering them with water-proofed duck cloth during threatening weather. In another, the piles were sprinkled periodically in an effort to simulate conditions existing during a wet season. The storage tests were carried for nine weeks, during which less than 2 inches natural precipitation fell. The watered piles received approximately 12 inches during this period. A third test was made to determine roughly the effect of allowing the beet tops to lay, unpiled in the field until well cured, before piling. These tops laid in the field five weeks before piling. They were then piled and sampled four weeks later.

The results are given in condensed form in Fig. I. The composition of the original tops in pounds of the various constituents per ton of tops are shown at the extreme left. The remainder of the chart shows the percentage of components originally present remaining after storage of 1, 2, 4, 6 and 9 weeks. In the three special tests only the results on nitrogen free extract and protein after nine weeks storage are shown. Sampling error probably accounts for most of the variations shown in nitrogen free extract and protein, though there was evidently a slow loss in nitrogen free extract. The protein loss was unimportant. Crude fiber tended to increase, probably because of contamination of the samples by much unburned coal dust from the factory near which the piles were stored. The high ash content after nine weeks storage resulted from excessive dirt accumulation, blown from the field while the pile was a mass of ice and snow. In the special tests the piles protected from precipitation lost more than the standard and the watered piles gave the same results as the standard. Sprinkling the piles had negligible effect, because in the dry air the water evaporated very rapidly. What little remained stayed frozen most of the time. Apparently curing in the field before piling retains most of the nutrients, but mechanical loss of the brittle leaves would cause pronounced loss in practice.

The conclusion is that under conditions normally existing in this territory, loss of nutrients from piled beet tops is not serious. Possibly if piles were made sufficiently large to permit heating and prevent access of air, compositing would occur with attendant large loss in nitrogen free extract.

LOSS OF NUTRIENTS FROM BEET TOPS DURING STORAGE IN FIELD
Great Western Sugar Co., Res. Lab.

Figure 1



BUSINESS SESSION
January 5, 4:00 P.M.

President N. R. McCreery, presiding.
The reports of the Secretary-Treasurer were read. They follow.

REPORT OF THE SECRETARY

The membership of the Society has been growing rapidly, the distribution being as follows:

	Individual	Company
Arizona	5	
California	43	3
Colorado	55	5
Dist. of Columbia	7	
Idaho	19	
Illinois	1	2
Indiana	1	1
Kansas	1	
Michigan	26	1
Minnesota	1	
Montana	10	1
Nebraska	11	
N. Mexico	1	
New York	2	
Ohio	12	
Oregon	1	
South Dakota	5	
Tennessee	1	
Utah	42	5
Washington	4	
Wyoming	8	
Total U. S.	256	18
Canada	8	
Argentina	1	
Belgium	1	
Denmark	1	
Italy	1	

Copies of the 1938 Proceedings were supplied to all of the charter members, to four libraries, and in exchange for publications by the following:

International Sugar Journal, England
Imperial Bureau of Plant Genetics, England
International Institute de recherches Betteravieres, Belgium
International Society of Sugar Cane Technologists
Canadian Committee on Sugar Analysis

There are on hand at the present time, 20 copies of the 1937 Proceedings of the Fort Collins Round Table, at which the genesis of this organization

took place, and 68 copies of its first meeting at Salt Lake City in 1938.

Some of the present membership will be dropped, no doubt, as a result of failure to pay the current dues, but it is anticipated that the new members will far more than make up for this loss. If each member will take it upon himself to encourage those who are eligible to apply for membership in the Society, continued growth will be assured.

Early in 1939 the Secretary collaborated with the President of the Society in a survey of experimental projects in United States and Canada dealing with various phases of sugar beet research. A total of 188 projects were listed with 100 project leaders, a mimeographed report being prepared showing this information in detail. This survey proved to be both enlightening and valuable in preparing for this Denver meeting, and it is recommended that this be revised early in the next biennium.

During the past biennium questions as to various points were raised by members. The Secretary may have delayed answer, dodged the issue, or exceeded his authority in such cases. It is my sincere hope that whenever this has occurred, you were patient and lenient and that as the Society establishes precedent or policies, the correct answers to such questions may be expedited.

Respectfully submitted,

(signed) H. E. Browbaker

Secretary

REPORT OF THE TREASURER

Since a report on the status of the treasury was not made at the First General session of this Society at Salt Lake City in 1938, I wish to submit herewith one report of the Treasurer for the year January 1 to December 31, 1937, and a separate report for the biennium January 1, 1938 to December 31, 1939.

Receipts 1937 (Jan.1 to Dec. 31)

Balance from banquet (Ft.Collins Round Table)	$20.25
Dues from individuals (81)	81.00
Contributed by Sugar Companies	120.00
Total receipts	$221.25

Disbursements 1937 (Jan. 1 to Dec. 31)

Entertainment for banquet (Ft. Collins)	$ 7.14
Mimeo. and mailing 125 copies Annual Report	64.90
Stationery and postage during year	27.39
Expenses in preparation for 1938 meeting at S.L.City	4.79
Total disbursements	$104.22
Balance on hand (Jan.1,1938)	117.03
Total income	$221.25

Receipts 1938-39 (Jan. 1, 1938 to Dec. 31, 1939)

Dues from individuals (7 at $1.00 for 1937)	$ 7.00
" " " (35 at 50¢, Eastern region 1938)	17.50
" " " (278 at $1.50, 1938)	417.00
" " " (1 at $2.00, 1938)	2.00
Company memberships and contributions	392.00
1 copy regional report	.50
Total receipts	$836.00
Balance on hand	117.03
Total income	$953.03

Disbursements 1938-39 (Jan.1, 1938 to Dec.31, 1939)

Programs and other expenses for Salt Lake City meeting	$ 70.69
Expenses of invited guests and editor	187.60
Postage	34.09
Supplies, telegrams, and telephone	23.66
Reports of Salt Lake City meeting, including mailing (350 copies)	229.68
Expenditures connected with 1939 regional meeting at Fort Collins	30.46
Mimeographing report of 1939 regional meeting at Ft.Collins	37.04
Printing for 1940 meeting	17.08
Total disbursements	$630.30

Total income	$953.03
Total disbursements	630.30
Bal. in checking acct.1/1/40	$322.73

It will be noted from the foregoing report that the Eastern Region collected and transmitted to the General Secretary-Treasurer $17.50 as a balance from the 1939 regional meeting. For the Eastern Slope and Intermountain region, the total receipts for the 1939 meeting amounted to $118.50 for 79 memberships at $1.50 each with expenditures of $67.50, leaving a balance of $51.00 which accrued to the General Treasury.

Respectfully submitted,

(signed) H. E. Brewbaker

Treasurer

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RECORD OF THE MINUTES OF THE MEETING

The proposed changes in the Constitution and By-Laws which had been sent to all members in advance of the meeting were discussed, both the old and the changed versions being read.

Scott moved the changed form of Article VI be amended to include one member for Eastern and one for Western Canada. Passed.

Skuderna moved changed form of Article VII be amended to provide a committee of 5 members instead of 3. Palmer moved that this be further amended to provide for 2 nominations for only the officers. This was ruled in order by the President. Passed.

Carsner offered an amendment to the changed form of Article VII to make the Secretary-Treasurer's office a permanent one, and that the nominating committee be required to present only one name for this office. Passed.

Brown moved changed form of Article X be amended to add "upon approval of the Executive Committee" to the provision for holding Regional meetings under the auspices of the Society. Passed.

Coke moved By-law 1, sentence 2, be changed to read "recommended" instead of "determined." Passed.

Schmitt moved adoption of general changes in the Constitution and By-Laws as amended. Passed.

The nominating committee, consisting of E. Carsner, P. H. McMaster and Roy H. Cottrell presented nominations in accordance with new provisions of the Constitution. No new nominations were made from the floor. The officers and Advisory Council were elected as follows:

Officers:

President	J. E. Coke
Vice President	H. D. Brown
Secretary-Treasurer	H. E. Brewbaker

Advisory Council:

West Coast	C. A. Lavis
	C. J. Moroney
Intermountain	W. Y. Cannon
	H. A. Elcock
Eastern Slope	C. E. Cormany
	D. J. Roach
	A. W. Skuderna
Eastern U. S.	F. R. Bach
	M. J. Buschlen
Eastern Canada	Henry Stokes
Western Canada	A. E. Palmer
At Large	G. R. Hill
	W. W. Robbins

Resolutions proposed by the resolutions committee were adopted as follows:

The American Society of Sugar Beet Technologists assembled at Denver, Colorado, on the 4th, 5th and 6th day of January, 1940, at its Second General Meeting does hereby resolve:

(1) That the Society expresses to the Great Western Sugar Company and the American Crystal Sugar Company their appreciation for the genuine hospitality which has been extended to each of the members in attendance.

(2) That Dr. H. K. Hayes, Dr. D. R. Hoagland and Professor H. C. Rather contributed greatly to the success of this meeting by their willing counsel and their excellent surveys of the field agricultural research in which each is so well known.

(3) That the assistance given by the Denver Tourist Bureau is greatly appreciated.

(4) That the interest manifested by Hon. Ralph Carr, Governor of Colorado, and Mayor Benjamin F. Stapleton of the city of Denver, in the sugar beet industry and this organization is highly valued by the members.

(5) That a research coordinating committee of three be appointed by the chairman to (1) study and analyze the sugar beet experimental projects of sugar companies, experiment stations, the U.S.D.A.,

and Dominion of Canada (2) to study the major production problems of the sugar beet industry and (3) to from time to time make progress reports.

(6) That the Society accept the invitation of the Utah-Idaho and Amalgamated Sugar Companies to hold the 1942 General Meeting at Salt Lake City.

J. E. Coke, Chairman of the Committee
C. E. Cormany
F. V. Owen
H. D. Brown
T. H. Ferril

A report of the Committee on Standardization of experimental methods was presented by the chairman, C. W. Doxtator, as follows:

REPORT OF COMMITTEE ON STANDARDIZATION OF EXPERIMENTAL METHODS 1/

The Standardization Committee presents the following recommendations as an acceptable basis for field plot tests, including experiments with varieties, fertilizers, and cultural practices. These recommendations are to be construed as general and not as mandatory for all kinds of conditions, it being fully recognized that sufficient control for one field might be quite insufficient for another.

Field experiments have been classified for this purpose into three groups:

1. Demonstrational - investigational tests.
2. Experimental tests with less than 25 varieties or treatments.
3. Experimental tests with 25 or more varieties or treatments.

Group 1 Demonstrational-investigational tests

With strip tests comparing two varieties or treatments paired strips should be 4 or more rows in width. Harvest entire strip, or if this is impractical, paired samples may be taken. If the latter method is used, pairs of samples, each sample not less than 2 rows by 30 ft. in length, are to be harvested for yield. The entire sample, or 20 roots taken at random from the sample, is to be used for the determination of percent sucrose and purity.

Paired samples should be taken as close together as possible allowing for border rows between the paired plots. Each pair of samples should be separated by approximately 100 feet in the row. Strips should preferably be replicated.

Group 2 Experimental tests with less than 25 varieties

For variety tests in which the total number of varieties does not exceed 24 the randomized block method is recommended. Plots should be 4 to 8 rows wide and 60 to 100 feet long, replicated a minimum of 6 times. For more critical experiments, the number of replications could be increased to ten. Latin Square arrangements are acceptable.

1/ Includes revisions by the Standardization Committee of 1939-40 which were approved by the Association at the General Meeting, January 5-7, 1940.

Two samples of not less than 15 to 20 beets per plot are recommended for sucrose and purity determinations. Each sample should be taken at random from the entire plot, preferably, previous to piling.

Group 3 Experimental tests with 25 or more varieties

In variety tests where the total number of varieties or breeding strains exceeds 24, the two dimensional qusi-factorial design with three groups of sets is recommended. The incomplete block design is also recommended for tests involving 25 or more varieties. Since these tests will be used largely on new strains in the breeding experiments smaller plots than recommended under No. 2 will often be necessary.

It is recommended that the following reference be used by workers in this field: Goulden, C. H. STATISTICAL METHODS. John Wiley and Son, New York, 300 pages, 1939.

Methods of Harvesting

In demonstrational-investigational tests (1) harvest of all beets in the plot disregarding the competition factor is recommended. In experimental tests (methods 2 and 3) it is recommended that stand counts and yield of the entire plot or sampled area be taken. It may be advisable in certain cases to take competitive beet yields also.

Methods of Recording Data

See type example:

Type Example

VARIETY TEST - UTAH - 1937

Variety	TONS PER ACRE		Percent		Beets per 100' Row
	Available Sugar	Beets	Sucrose	Purity	at Harvest
1	3.316	24.05	15.97	86.40	132
2	3.175	22.47	16.55	87.05	134
3	3.151	23.12	15.69	86.89	133
4	3.121	22.54	16.12	86.48	132
5	3.119	22.34	15.97	87.48	130
6	3.041	20.66	16.85	88.45	133
7	2.989	21.92	16.16	86.01	131
8	2.822	21.16	15.64	85.57	134
Mean	3.092	22.28	16.12	86.79	
S.E. of MEAN	0.078	0.56	0.13	0.49	
Sig.Diff.(19:1)	.222	1.58	0.50	1.39	

(Odds 19:1 = 2 x S.E. of Mean Diff. (Leave space blank if F. value not significant)

VARIANCE TABLE

Variation Due to	Degrees of Freedom	MEAN SQUARES Available Sugar	Tons Beets	Percent Sucrose	Purity
Between Blocks	7	1.655	9.727	1.855	7.866
Between Varieties	7	0.119	8.583	1.638	6.444
Remainder (Error)	49	0.049	2.490	0.249	1.945
Total	63				
Calculated F Value	----------	2.43*	3.45**	6.58**	3.31**

* Exceeds the 5% point of significance (F = 2.21)
**Exceeds the 1% point of significance (F = 3.03)
Plots: 4 rows 125 feet in length
Arrangement: Randomized blocks with 8 replicated plots of each variety
Planted April 20; Harvested October 24.

Respectfully submitted,

COMMITTEE ON STANDARDIZATION OF EXPERIMENTAL METHODS

C. W. Doxtator, Chairman
H. E. Brewbaker
C. E. Cormany
W. H. Leonard
Bion Tolman

Business session adjourned.

H. E. Brewbaker
Secretary-Treasurer

CONSTITUTION AND BY-LAWS OF THE AMERICAN SOCIETY OF SUGAR BEET TECHNOLOGISTS AS REVISED AT THE SECOND GENERAL MEETING

- - -

Name

ARTICLE I

The name of this organization shall be the AMERICAN SOCIETY OF SUGAR BEET TECHNOLOGISTS.

Object

ARTICLE II

The object of this Society shall be to foster all phases of sugar beet and beet sugar research, and to act as a clearing house for the exchange of ideas resulting from such work.

Membership

ARTICLE III

Section 1. There shall be two classes of membership, namely "Active" and "Associate."

"Active" membership shall consist of those individuals or organizations which are on the Secretary's list as such and who have paid their biennial dues.

"Associate" membership shall consist of those who register at general or "regional" meetings of the Society but who do not pay the biennial dues, and such libraries, journals, etc., with whom the Executive Committee decides to provide reports or exchange publications.

Section 2. Active membership shall be limited to charter members of the Society in good standing and to those who have been recommended in writing by two active members, passed by the Executive Committee, and who have paid the current biennial dues to the Society.

Section 3. Any member may be deprived of membership for non-payment of dues or for other reasons by vote of the Executive Committee of this Society.

Sections

ARTICLE IV

Section 1. In order to provide opportunity for the consideration of specialized subjects in all branches of sugar beet research, Sections shall be organized as needed.

Section 2. The division of subject matter among the sections shall be as follows:

(a) General agronomy including soils, fertilizers, field production and by-products.
(b) Genetics, breeding, seed and varieties.
(c) Plant diseases and insect pests.
(d) Sugar beet machinery.
(e) Chemistry.

Officers of the Society

ARTICLE V

The officers of the Society shall be a President, Vice President, and Secretary, who shall act as Treasurer. These officers, together with the immediate past president, shall constitute the Executive Committee.

ARTICLE VI

The Advisory Council shall consist of the following representatives: West Coast 2, Intermountain area 2, Eastern Slope 3, Eastern U.S. 2, Eastern Canada 1, Western Canada 1, and At Large 2.

Election of Officers and Advisory Council of the Society

ARTICLE VII

The President shall appoint a Nominating Committee of five members in advance of the regular meeting. This Committee shall nominate two candidates for each of the officers of the Society, except the Secretary-Treasurer, which shall be considered permanent, and for which only one candidate may be named. Nominations for the Advisory Council shall be made by the Nominating Committee in counsel with the Society members assembled from each area; the nominations for members at large to be made by the Nominating Committee. Further nominations may be made from the floor.

Duties of Officers of the Society

ARTICLE VIII

Section 1. The President shall be the Executive Officer of the Society. He shall preside over the meetings of the Society and its Executive Committee.

He shall with the advice of the other members of the Executive Committee, appoint the General Program Chairman.

He shall continue to serve on the Executive Committee for the Society for two years following his retirement from the Presidency.

Section 2. The Secretary-Treasure shall keep the records of the Society. He shall attend to the collection of dues and accounts and payment of bills and obligations.

He shall collect the manuscripts on the general program and transmit them to the editor (when elected) for publication.

Section 3. The Executive Committee in consultation with the Advisory Council shall formulate the policies of the Society as a whole, subject to the approval of the Society.

The Executive Committee shall coordinate the activities of the different sections.

The Executive Committee shall act upon all matters within the jurisdiction of the Society which arise between meetings of the Society.

Program Chairmen and their Duties

ARTICLE IX

The General Program Chairman shall with the advice of the Executive

Committee appoint a chairman for each of the sections.

Each Sectional Chairman shall develop and submit to the General Program Chairman a tentative program for his Section and shall be responsible for conducting the sectional meetings at the general meetings of the society.

Time and Place of Meetings

ARTICLE X

General meetings of the Society shall be held biennially. The place of the meeting shall be determined at the previous general meeting of the Society, and due notice given to the members.

Regional meetings may be held under the auspices of the Society upon approval of the Executive Committee.

By-Laws

1. DUES - Biennial dues for membership in the Society shall be $2.50 for individuals. The membership dues for companies shall be recommended by the Executive Committee and Advisory Council at each general meeting of the Society in relation to the needs of the organization. Members paying the individual or company fee shall be entitled to receive all of the official communications of the Society and to participate in all its activities.

A registration fee of $1.00 shall be charged those attending any general meeting of the Society who are not members. This fee will carry Associate membership and may be applied as part payment on the regular fee if application for membership is made out at time of registration.

2. PUBLICATIONS - All papers listed in the program of any general meeting, or suitable abstracts thereof, shall, on recommendation of the General Program Chairman and with the approval of the Executive Committee, be published in the Proceedings of the Society. All papers not approved by the General Program Chairman shall be reviewed and passed upon by the Executive Committee.

Reports of Regional meetings shall not be considered official publications of the Society. Active or associate members shall have the privilege of purchasing Regional proceedings by request of the Secretary of the Society previous to printing the Proceedings.

3. COMMITTEES - The Society and Sections shall appoint such standing and special committees as seem desirable for carrying on the work of the Society or Section.

4. QUORUM - A quorum for the general meeting shall consist of 10 per cent of the active members.

5. AMENDMENTS - These By-Laws may be amended at any general meeting by two-thirds vote of the members present.